The Real Costs of Authenticity: Integrating ISLE and Project-Based Learning

How CTE Students Learn to Think Like Scientists While Preparing for Diverse Futures

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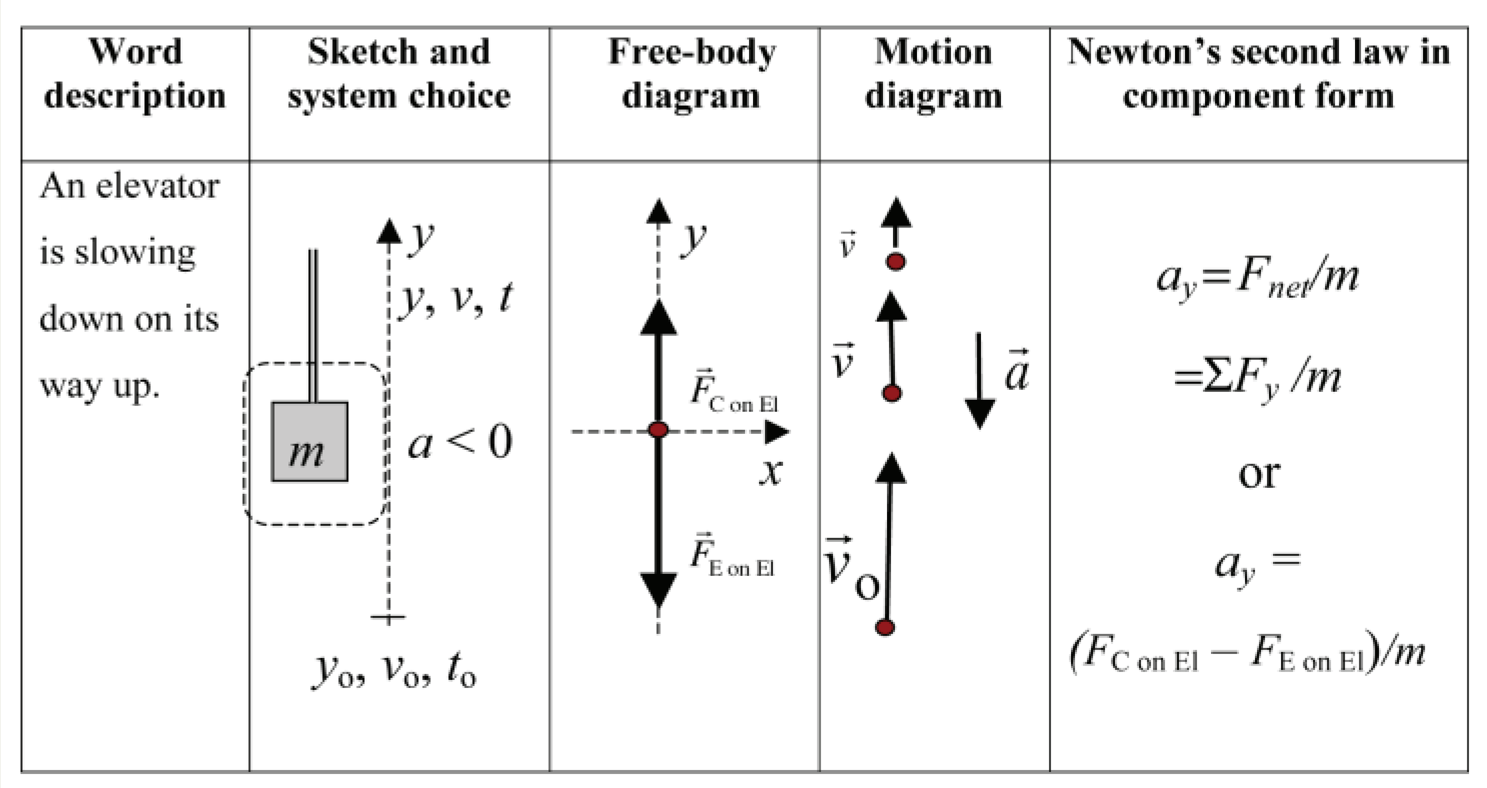
Teaching Physics for Real World Learning

Same classroom. Different futures. Can physics thinking serve both?



Word description	Sketch and system choice	Free-body diagram	Motion diagram	Newton's second law in component form
An elevator is slowing down on its way up.	y y, v, t m $a < 0$ y_o, v_o, t_o	y $\vec{F}_{\text{C on El}}$ x $\vec{F}_{\text{E on El}}$	$\vec{v}$ $\vec{v}$ $\vec{a}$ $\vec{v}_o$	$a_y = F_{net}/m$ $= \Sigma F_y / m$ or $a_y =$ $(F_{\text{C on El}} - F_{\text{E on El}})/m$

Source: Etkina, Van Heuvelen, & Rosengrant (2008), The College Board AP Physics Special Focus

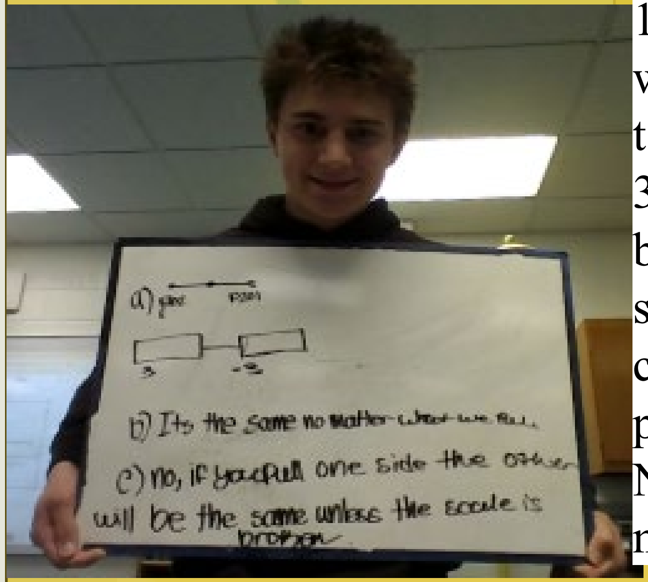
Investigative Science Learning Environment - ISLE foundation

- Intentionalities of ISLE
  - Students learn physics by practicing it
  - Students' well-being is enhanced

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



if F102 = -f201 and I run a testing experiments where 1 scale pulls another one with 3N, the result will be that the other scale will read 3N in the opposite direction, because Fs1ons2=-Fs2ons1 should apply in this pulling context therefore we are not proving that the 3rd Law of Newton works but we have not found how to break it

Student Perspectives on Scientific Thinking

1. Seatbelt Mechanism (Engineering Context) "I learned how a seatbelt worked and how to raise the height of headlights. Not being embarrassed to ask questions."
2. 3D Printer Setup (Technology Application): "when i setup my 3d printer i had to reread instructions to figure out what was messed up to be able to actually use it"
3. Car Battery Terminal Quote (Career-Technical Application): "With my mom's car battery, I figured out that in order to put the wires into the terminal, I had to strip the wire to keep the current together, and put one wire on top the other. I think people need to work on problem solving skills the most. Especially when it's something they can solve themselves."
4. Critical Thinking Quote (Universal Application): "Critical thinking. Everyday requires critical thinking at least once."
5. Understanding Mechanics Quote (Conceptual Thinking) "Thinking about how things work and the mechanics of it instead of just accepting answers people give."

Trout in the Classroom - Department of Natural Resources

Implement

# Days from egg arrival	Measurer	Day of Week	Date	Temp 58 F	PH 7.0-7.6	Ammonia NH3/NH4 < 0.5ppm	Nitrite NO2 < 0.50 ppm	Nitrate NO3 Best < 2 < 40 pp
PC5	ES5	Friday	11/21	75	8.2	8	0	0
PC5	ES7	Friday	11/21	75	8.2	4	0	0
PC8 before	ES5-GP1	Monday	11/24	75	8.2	4	0.5	5
PC8 after	ES7-GP1	Monday	11/24	75	8.2	4	0.5	5
PC8 after	Akamine	Monday	11/24	75	8.2	4	0.5	5

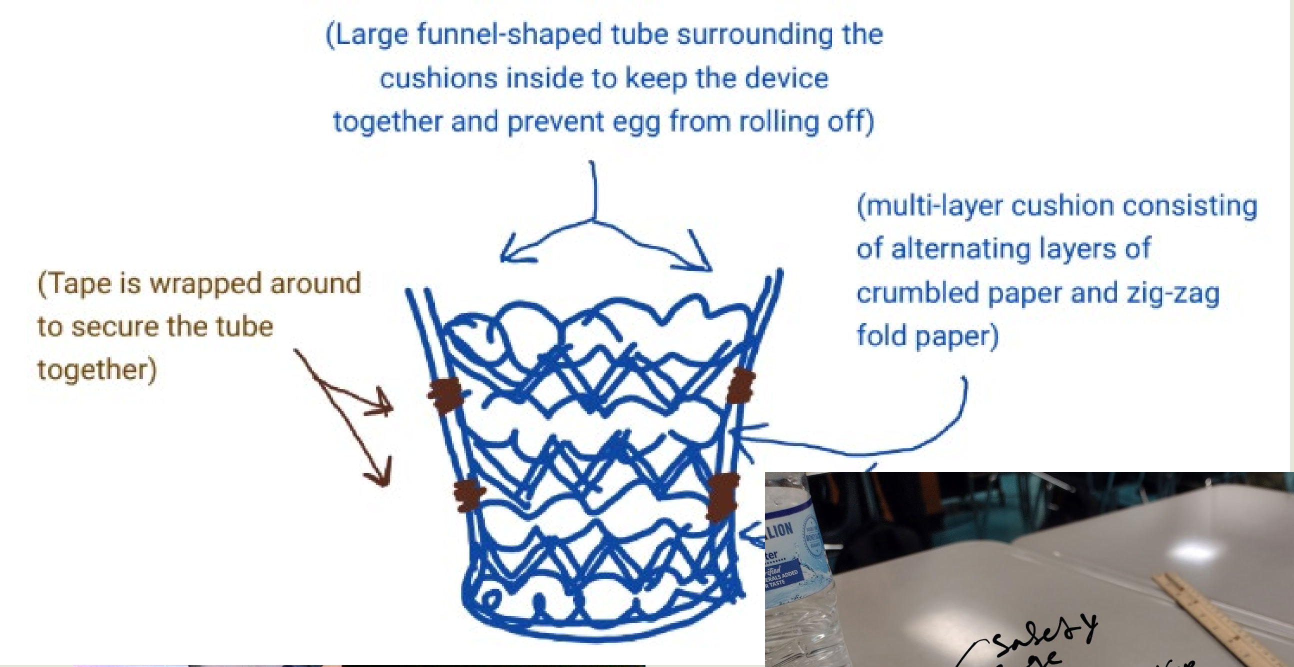
Challenge: Lack of spreadsheet knowledge
Solution: Working with spreadsheets regularly
Challenge: Working in groups
Solution Extracurricular projects: Must work in groups of student's choice

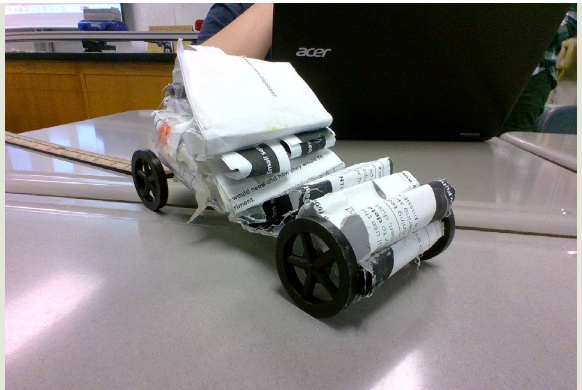
"We came up with this idea after reading research on light intensity and rainbow trout. We hypothesized that trout would prefer green light and avoid red light. After collecting videos and reviewing results, we found that green light actually made the fish more anxious and stressed. This proved our hypothesis wrong but educated us that fish do have different reactions to light." Students Report

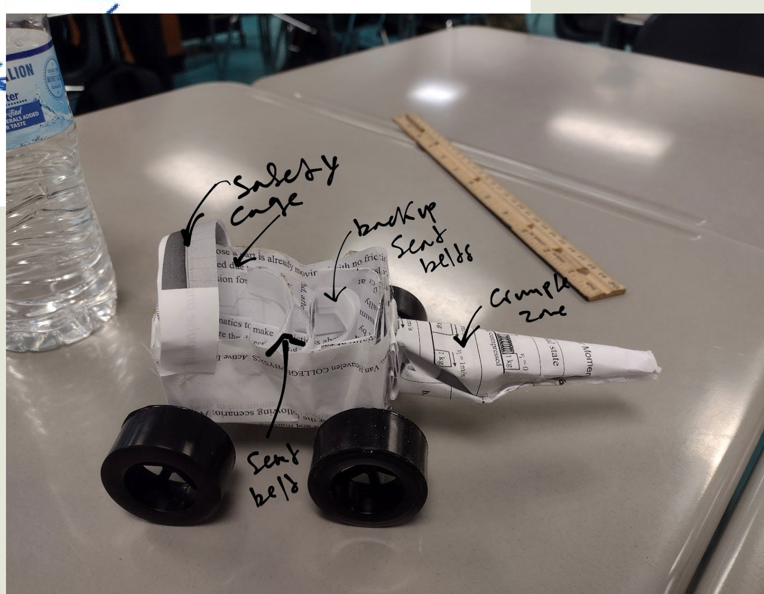
Crash Science in the Classroom - Insurance Institute for Highway safety

Implement

- Challenge: Collaboration and communications
- Solution: Make sure that projects have a facilitator and other roles. Practice roles and use them for groups
- Challenge: Substantial Time demand
- Solution: Allow students to retake quizzes but also redo their projects. New car, new egg drop catcher if they did not meet the criteria. Allowed students to work on it even if the class had already moved on. Independent work. I allowed them to catch up.
- Challenge: Achieving mastery and diagnostic feedback
- Solution: Students regularly self-assess their work and understand how to achieve it



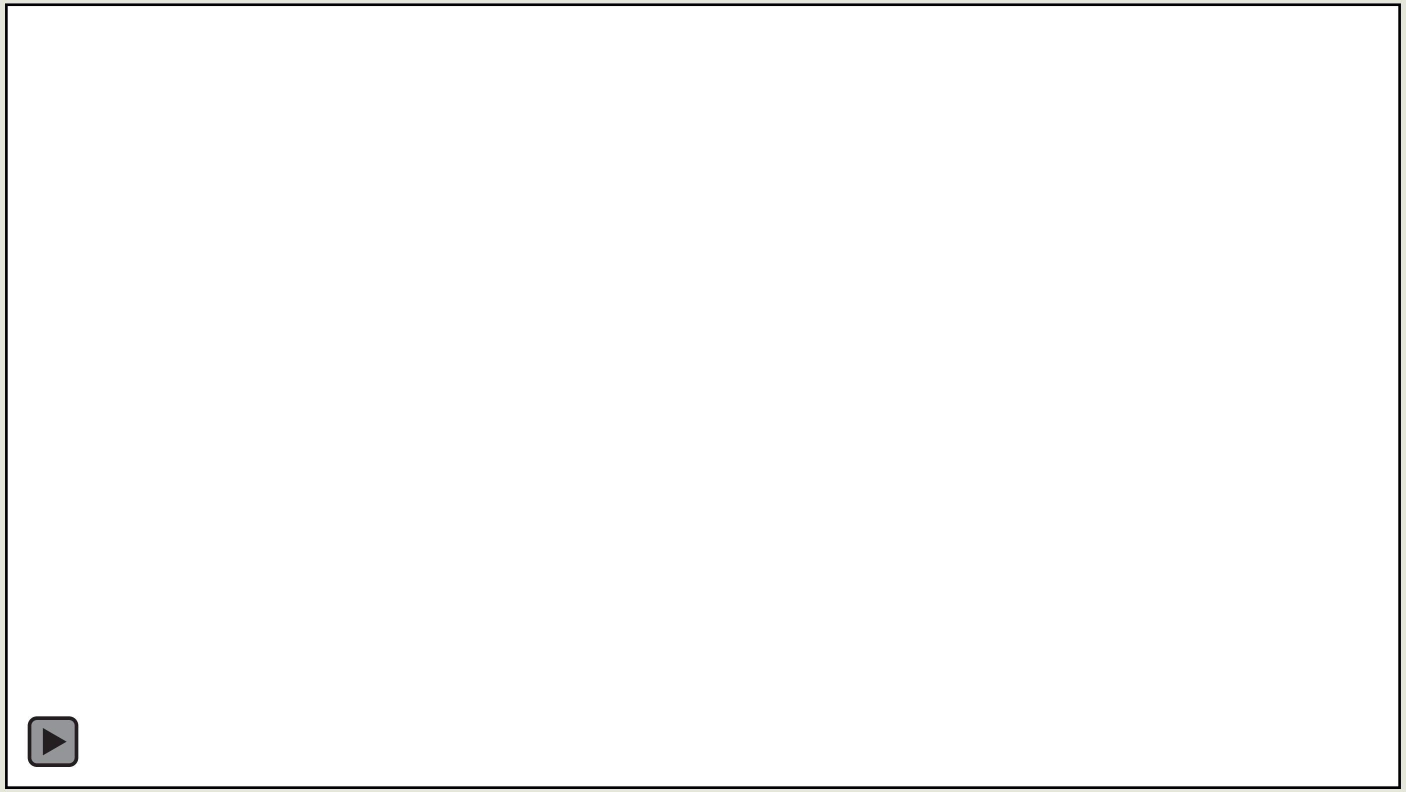




Rocket Club

Implement

- Student Challenge: A rocket was built and tested with two engines. Altitudes obtained were 150 ft and 420 ft. The computer simulation results were 221 ft and 484 ft respectively with a 41% error at lower altitudes and a 15% error at intermediate altitudes.
- Analysis: Use energy balance to make approximations.
- Solution: Use actual test data and calibrated real data to compensate for unknown physics ideal situations.

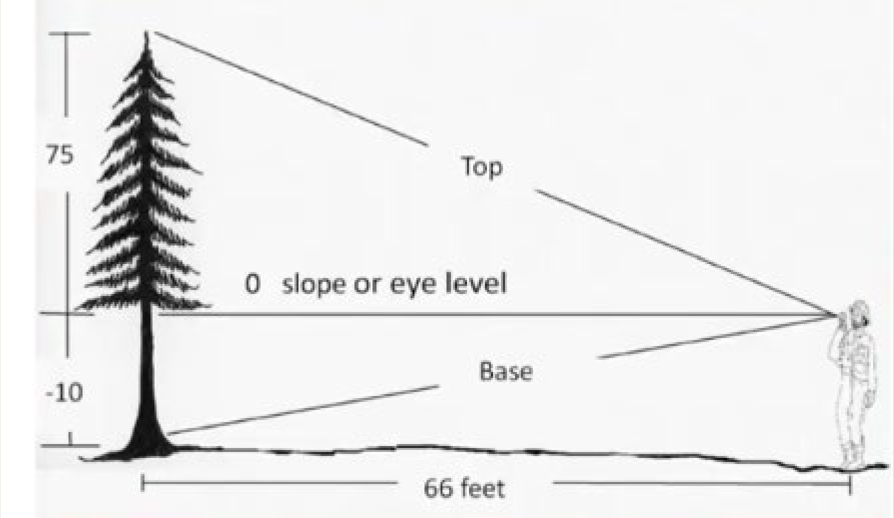


Source: Image taken at NARHAMs National Association of Rocketry Launch Site supported by Club #139

Envirothon – Department of Environment & Agriculture

Implement

Soil Ribbon Test: Force, pressure, permeability



Student led notes and problem solving

Challenge: Students that do not enjoy math. Solution: Students realize that mathematics is a tool, that we use to solve real-world challenges in the industry.

Soil permeability involves pressure, force, and fluid dynamics. Students apply the same experimental design and data analysis abilities they developed in physics class

Science Practices used and request for more

Evaluate

NGSS Science & Engineering Practice	% Used	% Request More
1. Asking Questions and Defining Problems	62%	28%
2. Developing and Using Models	**12%**	**19%**
3. Planning and Carrying Out Investigations	**18%**	**12%**
4. Analyzing and Interpreting Data	38%	31%
5. Using Mathematics and Computational Thinking	**22%**	**15%**
6. Constructing Explanations and Designing Solutions*	45%	47%
7. Engaging in Argument from Evidence	28%	24%
8. Obtaining, Evaluating, and Communicating Information	68%	22%

- Problem solving responses included under SEP 6 - Constructing Explanations and Designing Solutions:
- Critical thinking responses distributed across SEP 1 (Asking Questions), SEP 4 (Analyzing Data), and SEP 6 (Designing Solutions)

What I Would Do Differently Next Year

Evaluate

- **0. Student Voice:** "I am a snowboard instructor and i had to teach people how to snowboard over the break. Some people get the hang of it and some need a little more practice and explaining before they get the hang of it. [I] Tried different solutions, Thought through pros and cons.
- **1. Challenges:** Observe and implement practical solutions to real-world challenges.
- **2. Authentic Projects as Applications** Continue: Trout in the Classroom | Crash Science | Rocket Club
- **3. Demonstrate ISLE's Value:** ISLE foundation develops abilities AND meets content requirements. Create accountability through learning
- **4. New Projects:** Frame ISLE investigations around students' interests

3 minutes of Questions & Answers

Plan

Evaluate | Implement

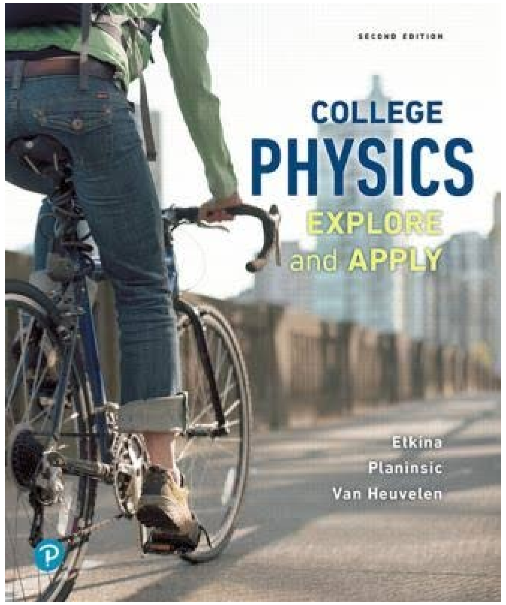
Acknowledgements

600students

BOYD J. MICHAEL III TECHNICAL HIGH SCHOOL — CTE

WCPS Washington County Public Schools

CSAAPT



pivot interactives

PUM

Takeaways

- **Foundation First**: Systematic ISLE ability development before authentic applications
- **Authenticity Matters**: Real problems with genuine uncertainty engage all students
- **Practical Challenges**: Address math gaps, collaboration skills, and time demands explicitly
- **Transfer is the Goal**: Students apply scientific thinking beyond the classroom

References

- Etkina, E., & Planinsic, G. (2023). *The Investigative Science Learning Environment: A guide for teacher preparation and professional development*. IOP Publishing. https://doi.org/10.1088/978-0-7503-5568-1
- Adapted from: Etkina, Van Heuvelen, & Rosengrant (2008), The College Board AP Physics Special Focus. https://secure-media.collegeboard.org/apc/Physics_Multiple_Representations_of_Knowledge_SF.pdf

Back up Slides

Abstract

Physics educators must develop students' scientific abilities through structured inquiry while engaging them in authentic applications—yet integrating these goals remains challenging. This practitioner action research examines the implementation of a progression model across 3.5 years in a Career and Technical Education high school (140 students annually across Earth and Space Science, Honors Physics, AP Physics 1), where students possess strong hands-on skills but variable mathematical preparation.

The foundation employed Investigative Science Learning Environment (ISLE) to develop experimental design, data analysis, and collaboration abilities. Authentic application used projects such as: Trout in the Classroom ecological monitoring, extended physics investigations and engineering projects, and extracurricular activities (Envirothon, Rocket Design).

Three major challenges emerged: prerequisite skill gaps requiring explicit instruction (mathematics, spreadsheet analysis), collaborative learning difficulties (communication, task distribution), and substantial time demands requiring flexible timelines for iterative troubleshooting and diagnostic feedback. Starting with ISLE to build a strong physics foundation, students can more successfully engage in project-based learning in physics and other science projects in the classroom, ultimately applying these skills to their daily lives.

Plan

The CTE Challenge: One Classroom, Two Pathways

Career Cluster	College Bound	Career Bound
Healthcare	Nursing Degree → Registered Nurse	CNA Certification → Nursing Assistant
Public Safety	Criminal Justice → FBI Agent	Police Academy → Officer
Construction	Civil Engineering → Engineer	Apprenticeship → Electrician
Transportation	Mechanical Eng → Designer	ASE Certification → Technician
Hospitality	Culinary Degree → Executive Chef	Culinary Cert → Sous Chef
IT (3%)	Computer Science → Developer	CompTIA A+ → IT Support

Source: Student program applications, WCPS Program of Studies. Developed with Colleague AI.

"When Physics Thinking Meets Real Problems"

Plan

NGSS Practice	Science Practices	Engineering Practices
Asking Questions and Defining Problems	Why/how does this occur?	What problem? What criteria/constraints?
Developing and Using Models	Build testable models; predict outcomes	Create prototypes to test solutions
Planning and Carrying Out Investigations	Design tests comparing predictions to observations	Design tests evaluating solution performance
Analyzing and Interpreting Data	Measure with uncertainty; compare to predictions	Compare performance against criteria
Using Mathematics and Computational Thinking	Quantify relationships; make predictions	Calculate specifications; optimize
Constructing Explanations and Designing Solutions	Model agrees with data? Revise	Design meets criteria? Iterate
Engaging in Argument from Evidence	Defend model; critique design/uncertainty	Justify decisions; evaluate trade-offs
Obtaining, Evaluating, and Communicating Information	Multiple representations (words, graphs, equations, diagrams, sketches)	Technical drawings; stakeholder presentations

Source: Adapted from NGSS Framework with science philosophy informed by Dr. Etkina's ISLE approach and author's teaching practice. Developed through iterative collaboration with Colleague AI.