PATHWAY 2 CAREERS

To find out what one is fitted to do, and to secure an opportunity to do it, is the key to happiness.

–John Dewey

What we'll cover

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WHO is P2C?

We're P2C!

We believe when education **becomes relevant**, learners can ***fully*** engage.

About the Company

P2C History

P2C (formerly NS4ed) was founded in 2016 by Dr. Joseph Goins with the mission to provide **high value research, policy, and educational materials** that yield actionable results for both the classroom and the workplace.

For nearly a decade, P2C has been at the forefront of **career-connected learning** with ready-to-implement solutions that work. Our products are supported by a career readiness model that increases student motivation and performance, while our research and support services have the capacity to alter policy and transform communities.

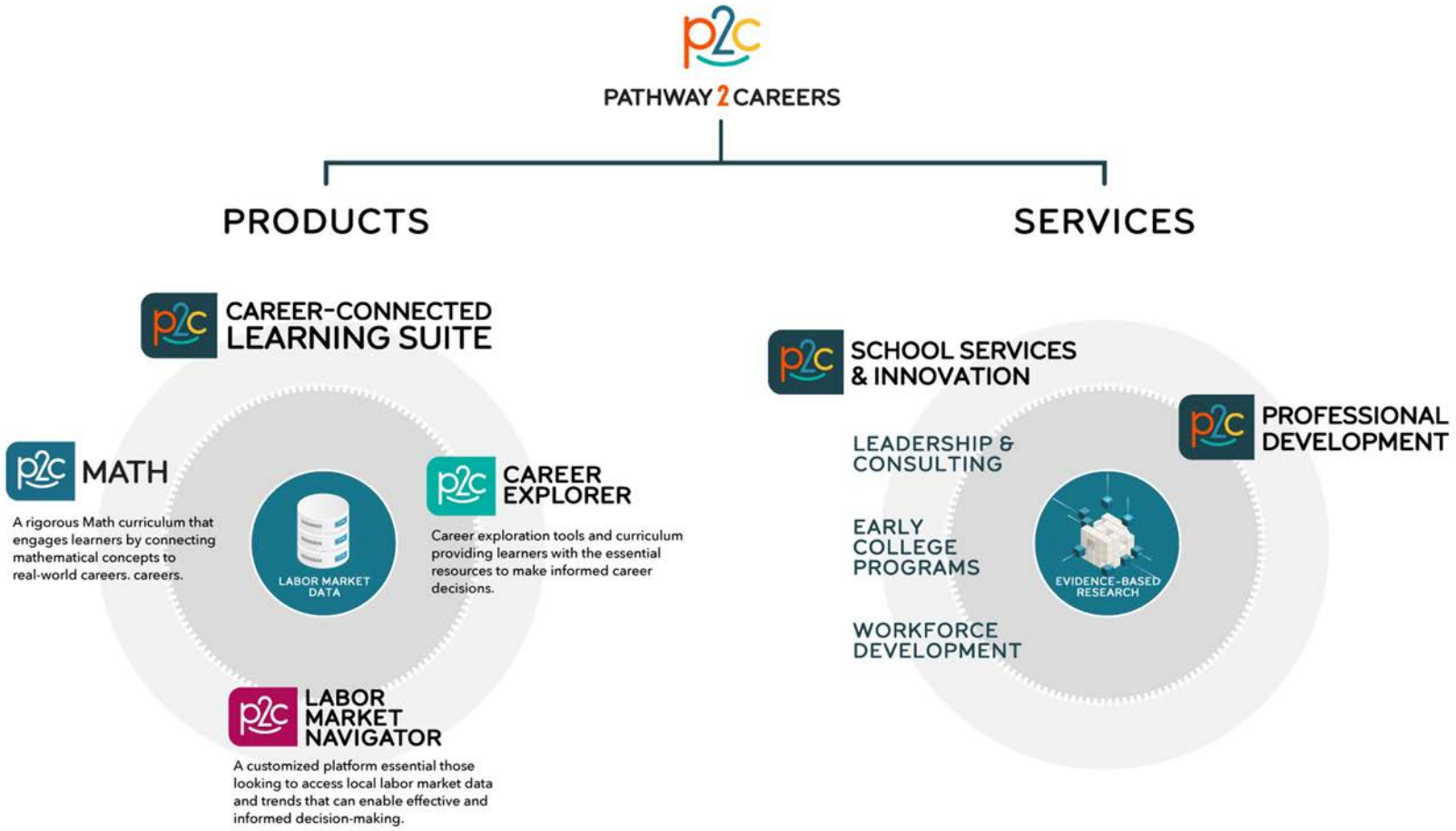
Our Mission

We’re dedicated to clearing the biggest hurdles in education by challenging current approaches and motivating student learning through career-connected relevance.

Our Vision

By connecting classroom and career paths, we believe we can transform not just the future prosperity of individual students, but the **economies of whole communities.**

WHAT is P2C?


PATHWAY 2 CAREERS
PRODUCTS
SERVICES
CAREER-CONNECTED LEARNING SUITE
MATH
A rigorous Math curriculum that engages learners by connecting mathematical concepts to real-world careers. careers.
LABOR MARKET DATA
CAREER EXPLORER
Career exploration tools and curriculum providing learners with the essential resources to make informed career decisions.
LABOR MARKET NAVIGATOR
A customized platform essential those looking to access local labor market data and trends that can enable effective and informed decision-making.
SCHOOL SERVICES & INNOVATION
PROFESSIONAL DEVELOPMENT
LEADERSHIP & CONSULTING
EARLY COLLEGE PROGRAMS
WORKFORCE DEVELOPMENT
EVIDENCE-BASED RESEARCH

RESEARCH

Supporting education initiatives and priorities with actionable research

POLICY

Validating policy issues in K-12, post-secondary, and business

PRACTICE

Data-informed and evidence-based practices to create a robust career readiness model

WHY P2C?

Why? Because when education becomes relevant, learners ***fully*** engage.

- Relevance yields **motivation**
- Relevance increases **career readiness**

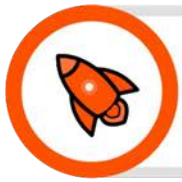
Motivation

Tell me and I forget, teach me and **I may** remember, involve me and I **learn.**

– Xun Kuang

Research shows...

When students experience **purpose** **in** their learning, there is an **increase** in:



Motivation to learn

(Frymier & Shulman, 1995; Jang, 2008)

Interest & engagement

(Assor, Kaplan, & Roth, 2002; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Hulleman & Harackiewicz, 2009)

Effort & persistence

(Trautwein & Ludtke, 2007; Yeager et al., 2014)

Task/course completion

(Fortenberry, Sullivan, Jordan, & Knight, 2007; Zusho, Pintrich, & Coppola, 2003)

Performance

(Hulleman et al., 2010; Hulleman & Harackiewicz, 2009; Malka & Covington, 2005)

Retention of new information

(Perin, 2001; Yeager et al., 2014)

The Effect of Motivation on Dropout Prevention

Strategy effect sizes from meta-regression model*

STRATEGY	EFFECT SIZE
Career development/job training	0.81
Family engagement	0.67
Mentoring	0.63
Behavioral intervention	0.46
Literacy development	0.42
Work-based learning	0.26
School/classroom environment	0.25
Service-learning	0.21
Health and wellness	0.18
Academic support	0.11

*Data sourced from the National Dropout Prevention Center

Career Readiness

Most high-paying jobs require additional education and training beyond a high school diploma.

We must make sure that our children, **particularly those who are traditionally underserved,** are prepared for and have access to postsecondary education.

– Gov. Bob Wise, Alliance for Excellent Education

The Gap Between Education & Industry

Education

57% of students who start a postsecondary program earn a degree within 6 years.

13% of **low income** students, earn a degree within 6 years.

The Gap Between Education & Industry

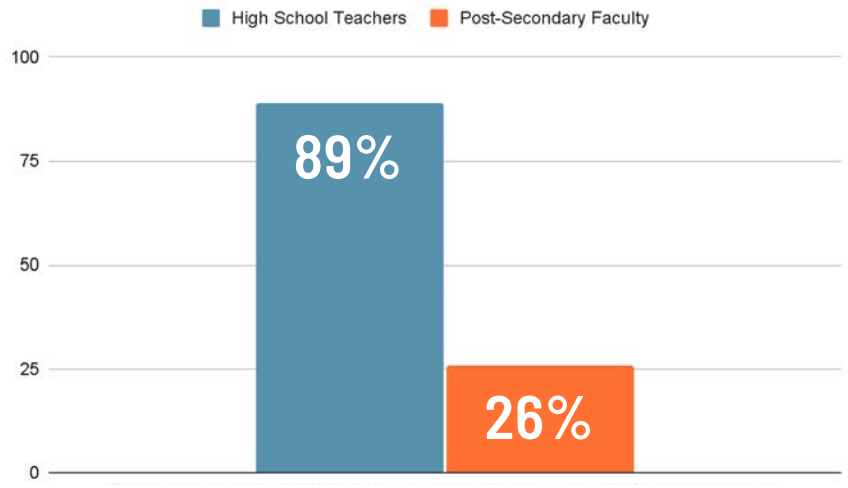
Education

Employment

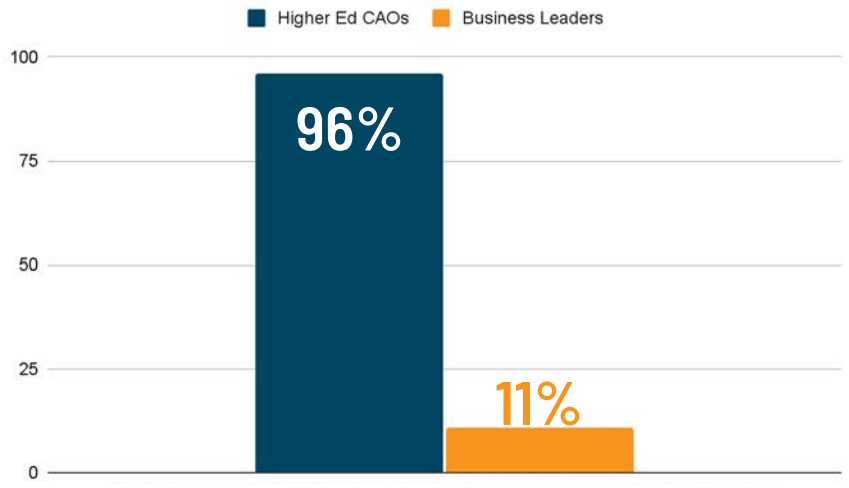
Economic Development

EQUITY ISSUES

The Gap Between Education & Industry



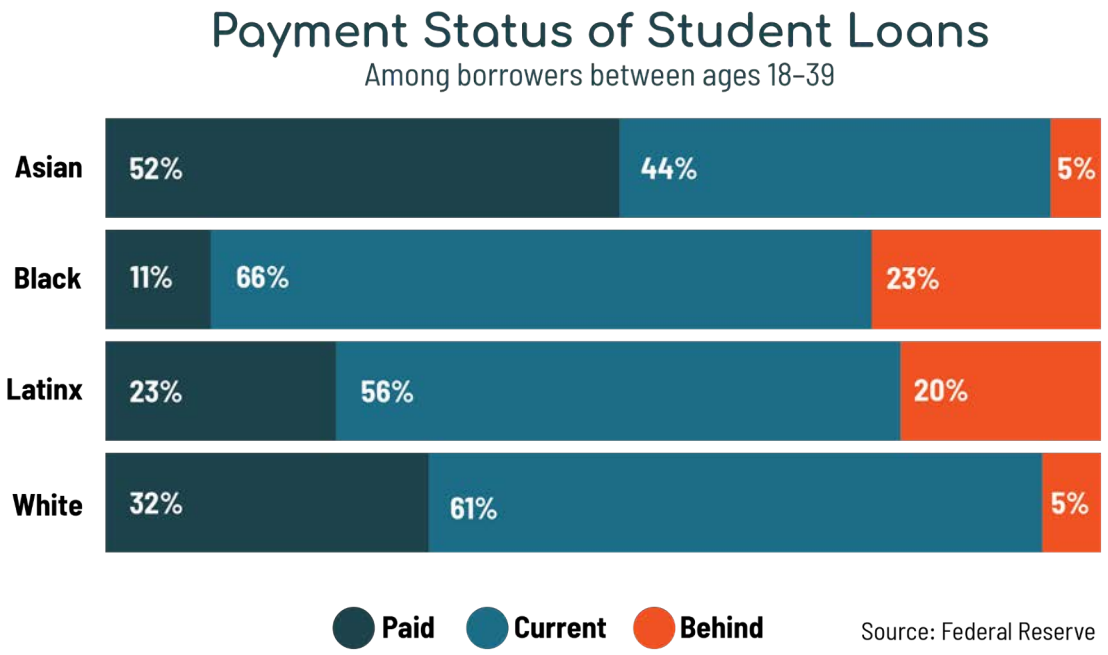
Percent who believe incoming higher ed freshmen are “ready”



Percent who have confidence that graduates have the skills required in the business world

Significant Long-Term Impact

When young people have **low employability,** they experience greater challenges in **reducing their student loan debt.**

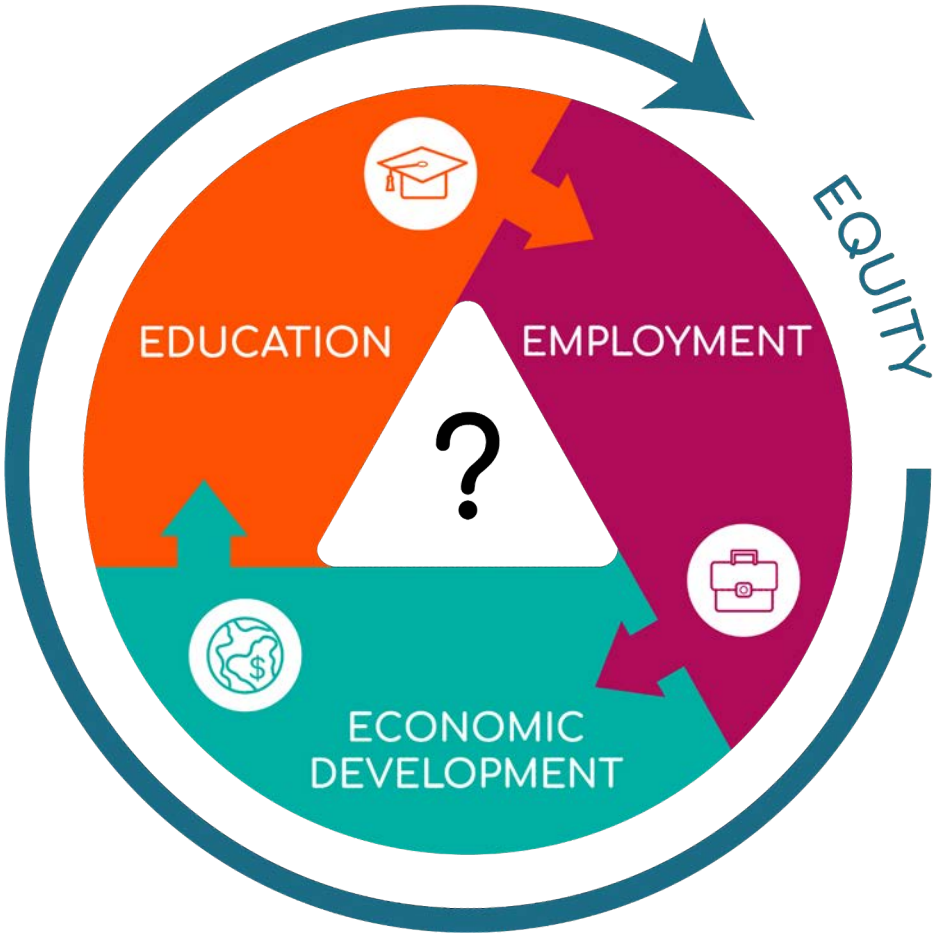


The Four "E"s

What is at the intersection of

education, employment, & economic development

that also addresses **equity** at each stage?



p2c PATHWAY 2 CAREERS

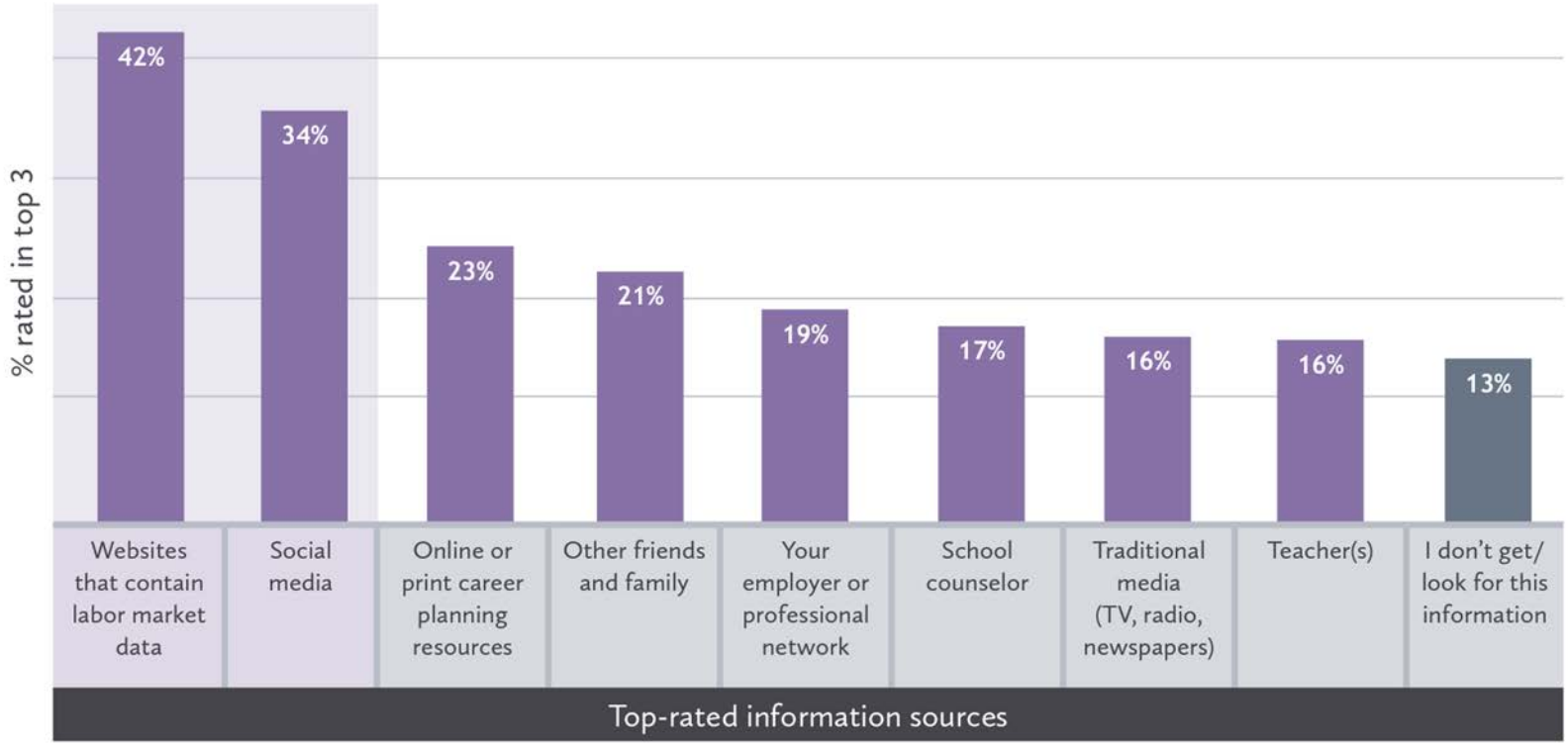
Product Spotlight

Labor Market Navigator

Benefits of Leveraging Labor Market Data

- Use labor market data to **understand career destinations** for students in their local areas.
- **Identify occupations** expected to be high in demand and wage.
- **Align educational practices** with critical skills.
- **Prioritize learning opportunities** that prepare students for good jobs in their communities.

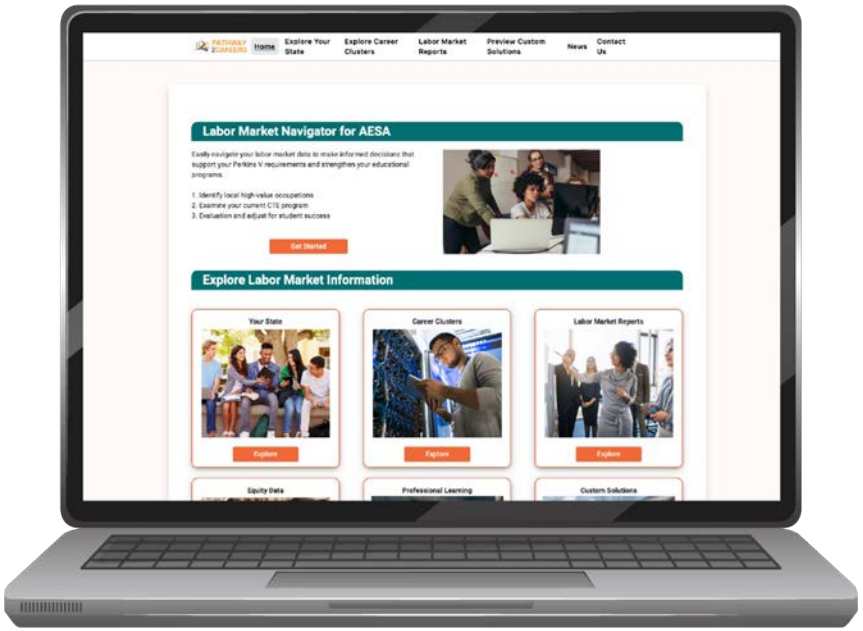
Where do students learn about careers?



Source

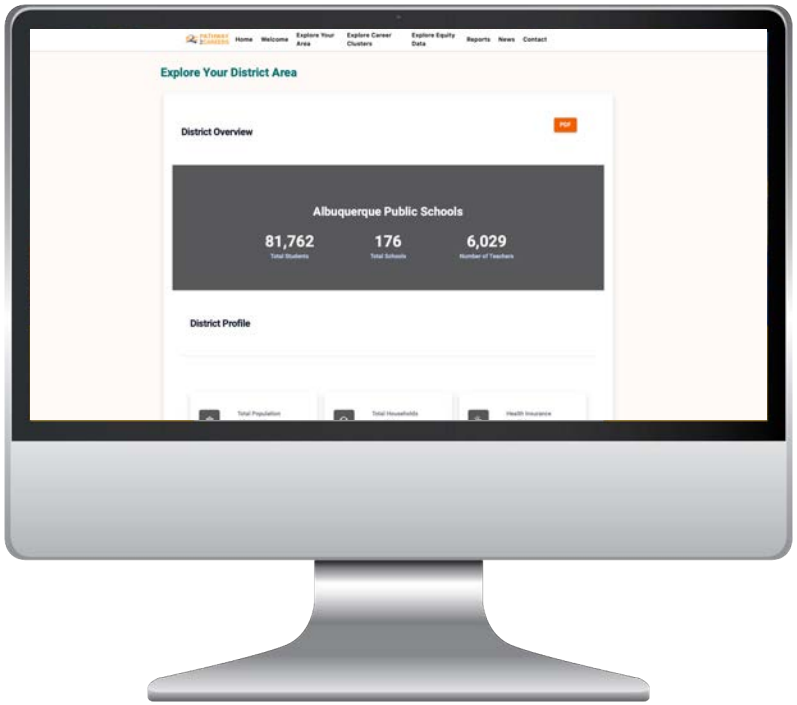
Labor Market Navigator (LMN)

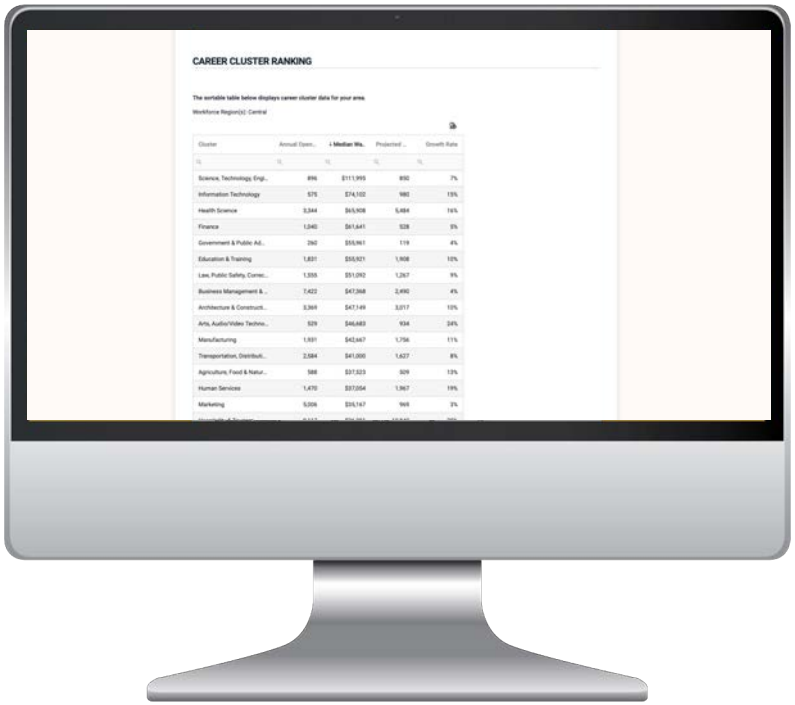
- The LMN dashboard makes the complicated simple.
- Educators and learners can navigate complex data in an engaging and digestible way.



Labor Market Navigator

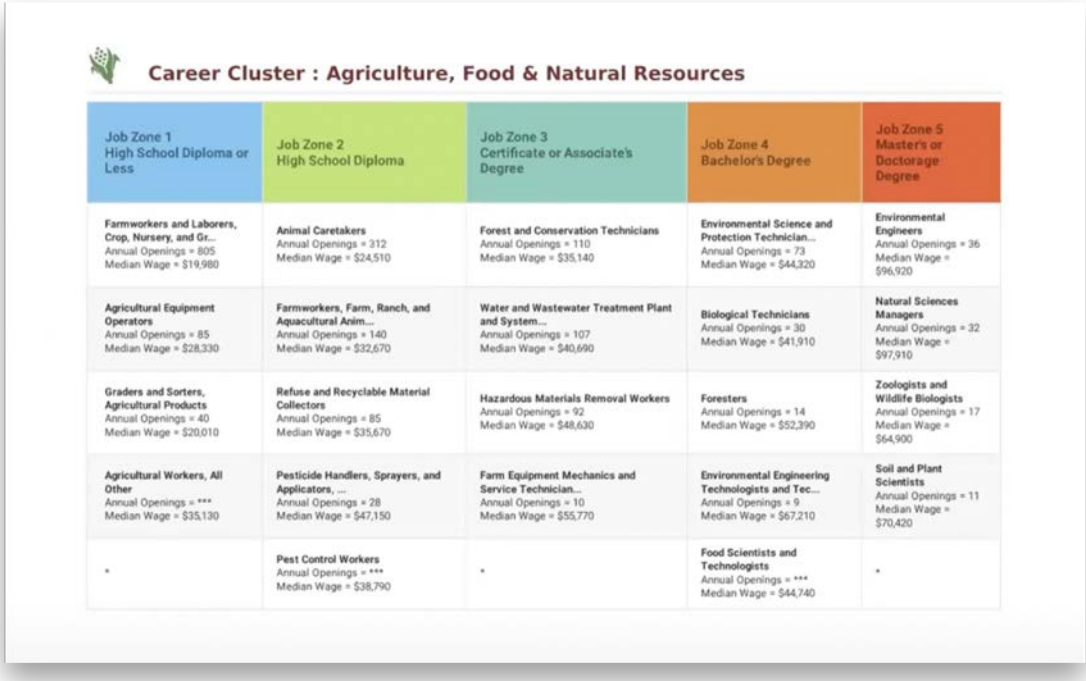
New Mexico case study





Labor Market Navigator

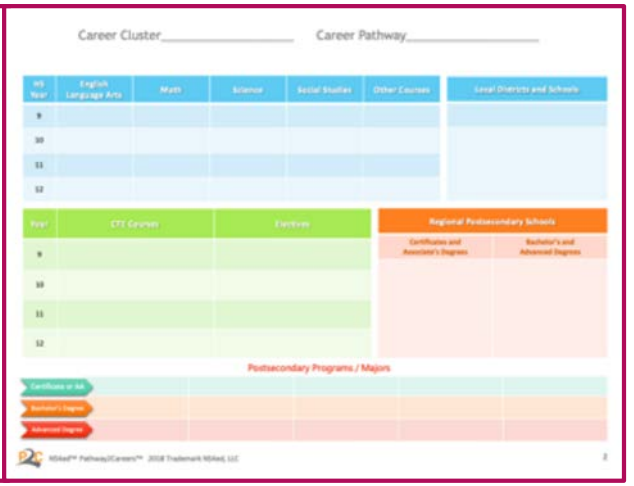
The career cluster results in the P2C labor market report allows you to overlay a skill or set of skills with relevant local job demand.



Career Cluster : Agriculture, Food & Natural Resources

Job Zone 1 High School Diploma or Less	Job Zone 2 High School Diploma	Job Zone 3 Certificate or Associate's Degree	Job Zone 4 Bachelor's Degree	Job Zone 5 Master's or Doctorage Degree
Farmworkers and Laborers, Crop, Nursery, and Gr... Annual Openings = 805 Median Wage = $19,980	**Animal Caretakers** Annual Openings = 312 Median Wage = $24,510	**Forest and Conservation Technicians** Annual Openings = 110 Median Wage = $35,140	**Environmental Science and Protection Technician...** Annual Openings = 73 Median Wage = $44,320	**Environmental Engineers** Annual Openings = 36 Median Wage = $96,920
Agricultural Equipment Operators Annual Openings = 85 Median Wage = $28,330	**Farmworkers, Farm, Ranch, and Aquacultural Anim...** Annual Openings = 140 Median Wage = $32,670	**Water and Wastewater Treatment Plant and System...** Annual Openings = 107 Median Wage = $40,690	**Biological Technicians** Annual Openings = 30 Median Wage = $41,910	**Natural Sciences Managers** Annual Openings = 32 Median Wage = $97,910
Graders and Sorters, Agricultural Products Annual Openings = 40 Median Wage = $20,010	**Refuse and Recyclable Material Collectors** Annual Openings = 85 Median Wage = $35,670	**Hazardous Materials Removal Workers** Annual Openings = 92 Median Wage = $48,630	**Foresters** Annual Openings = 14 Median Wage = $52,390	**Zoologists and Wildlife Biologists** Annual Openings = 17 Median Wage = $64,900
Agricultural Workers, All Other Annual Openings = *** Median Wage = $35,130	**Pesticide Handlers, Sprayers, and Applicators, ...** Annual Openings = 28 Median Wage = $47,150	**Farm Equipment Mechanics and Service Technician...** Annual Openings = 10 Median Wage = $55,770	**Environmental Engineering Technologists and Tec...** Annual Openings = 9 Median Wage = $67,210	**Soil and Plant Scientists** Annual Openings = 11 Median Wage = $70,420
*	**Pest Control Workers** Annual Openings = *** Median Wage = $38,790	*	**Food Scientists and Technologists** Annual Openings = *** Median Wage = $44,740	*

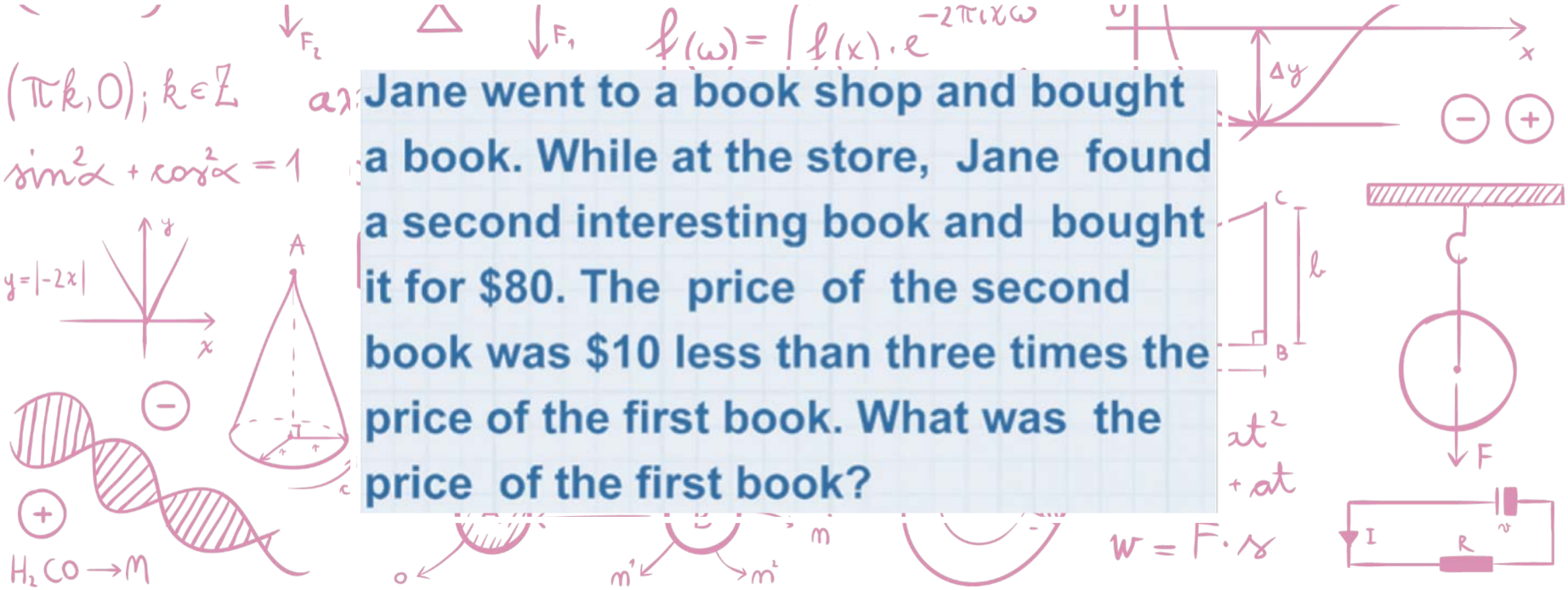
Additional Alignment Resources



Product Spotlight

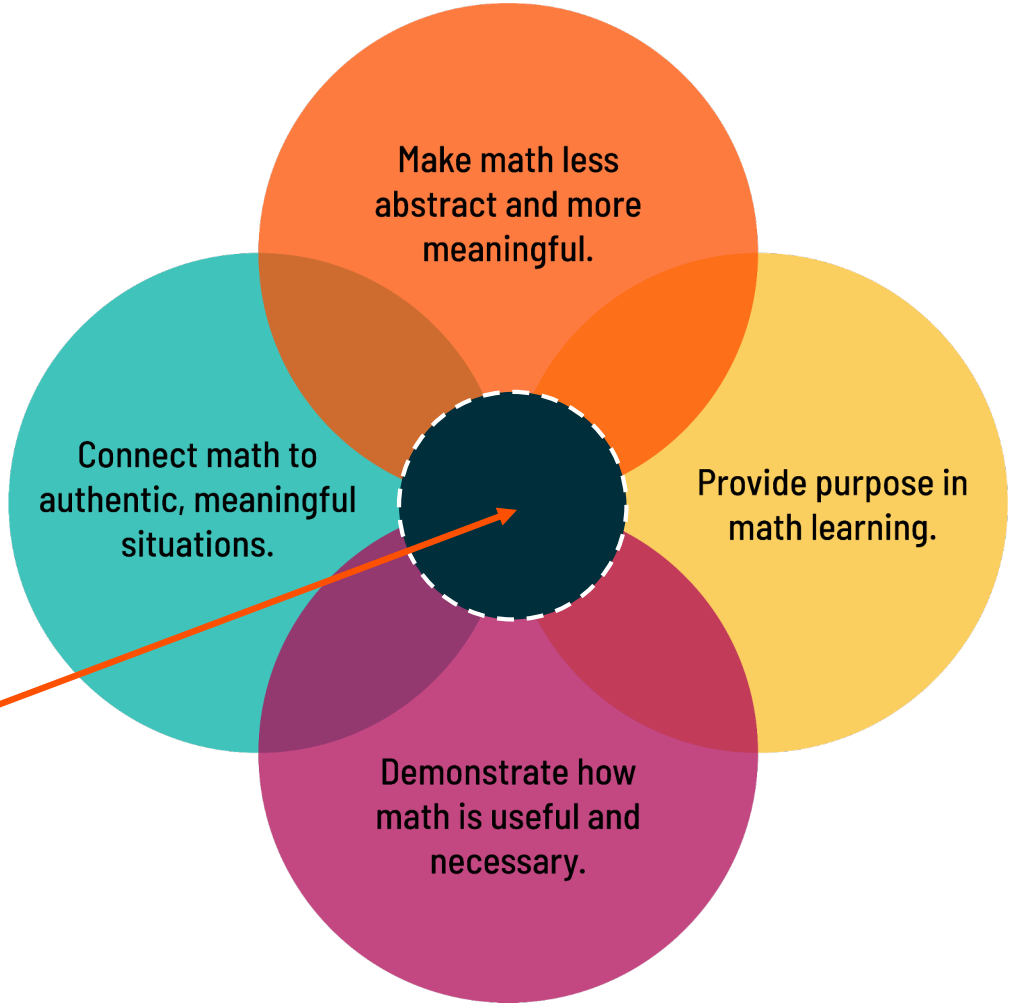
P2C Math

Traditional approaches to math education often look like this:



As math problems get more complex, studies have shown that students' attitudes toward math decline.

In order to modernize math, we must:



Career-Connected Learning

Benefits of Career-Connected Learning

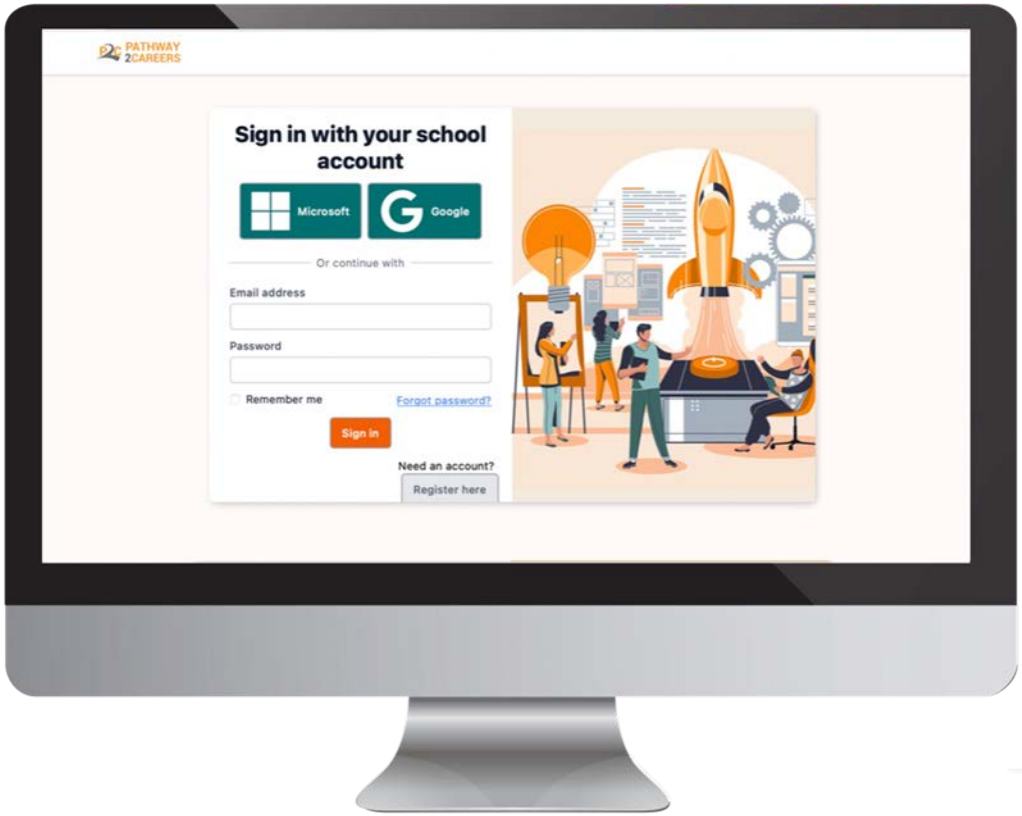
- Connecting math to careers can be a powerful approach to incorporate **purpose** into math learning.
- Doing so will improve students' **attitudes** toward math and enhance **motivation** to acquire the critical math skills students will need for **employment success.**

With Career-Connected Learning, students will see:

- how math is applied in **meaningful, everyday tasks.**
- the relationship between math proficiency and **successful job performance.**
- the value in using math to reach **job-related goals.**

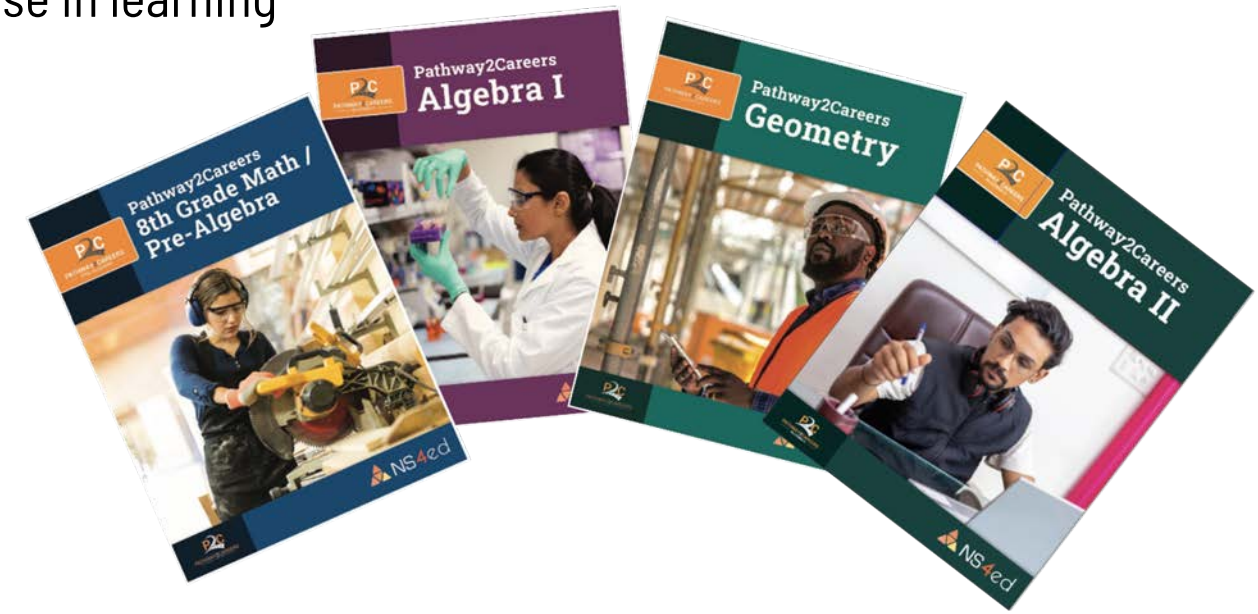
P2C Math connects curriculum to careers

- Comprehensive career exploration and pathway development system
- Connecting learning to the local/regional employers needs in the workforce



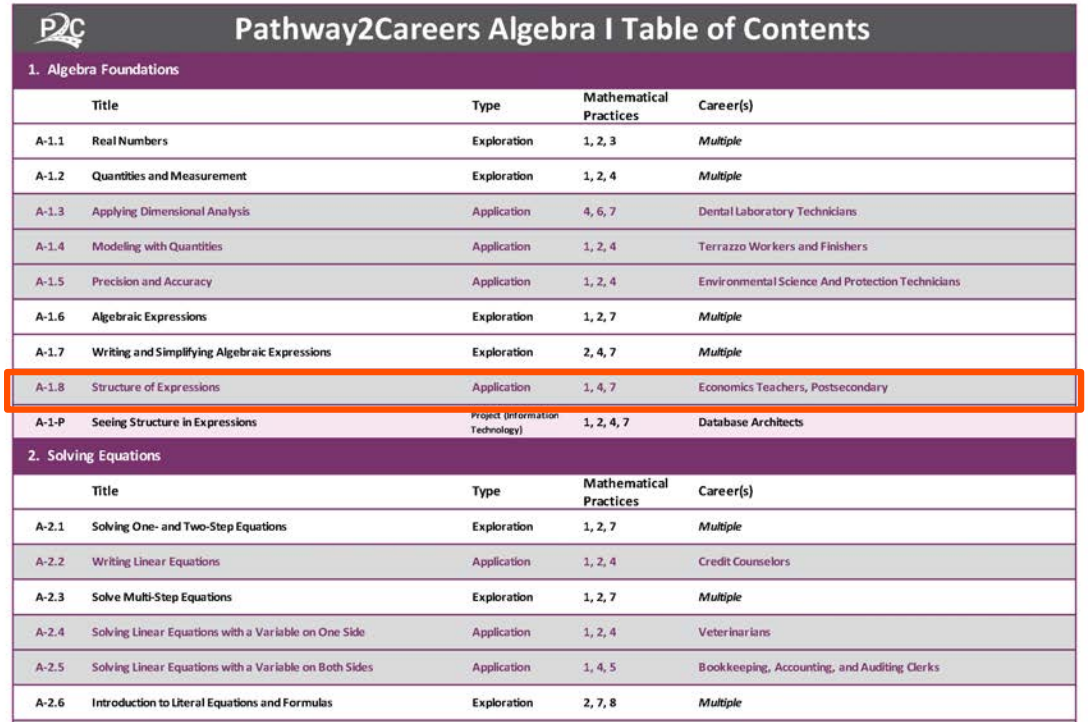
P2C Math Objectives

- Students understand the value of math skills in the workplace
- Students benefit from career exposure
- Students develop purpose in learning



650+ Careers to Discover

- Nearly 200 application lesson offers in-depth exploration of specific math concepts in the context of a spotlighted career.
- Occupations represent high-value careers in multiple fields.
    - High-Demand (O*NET Bright Outlook)
    - High-Wage (above $35,000)
    - All 16 Career Clusters



Pathway2Careers Algebra I Table of Contents

1. Algebra Foundations

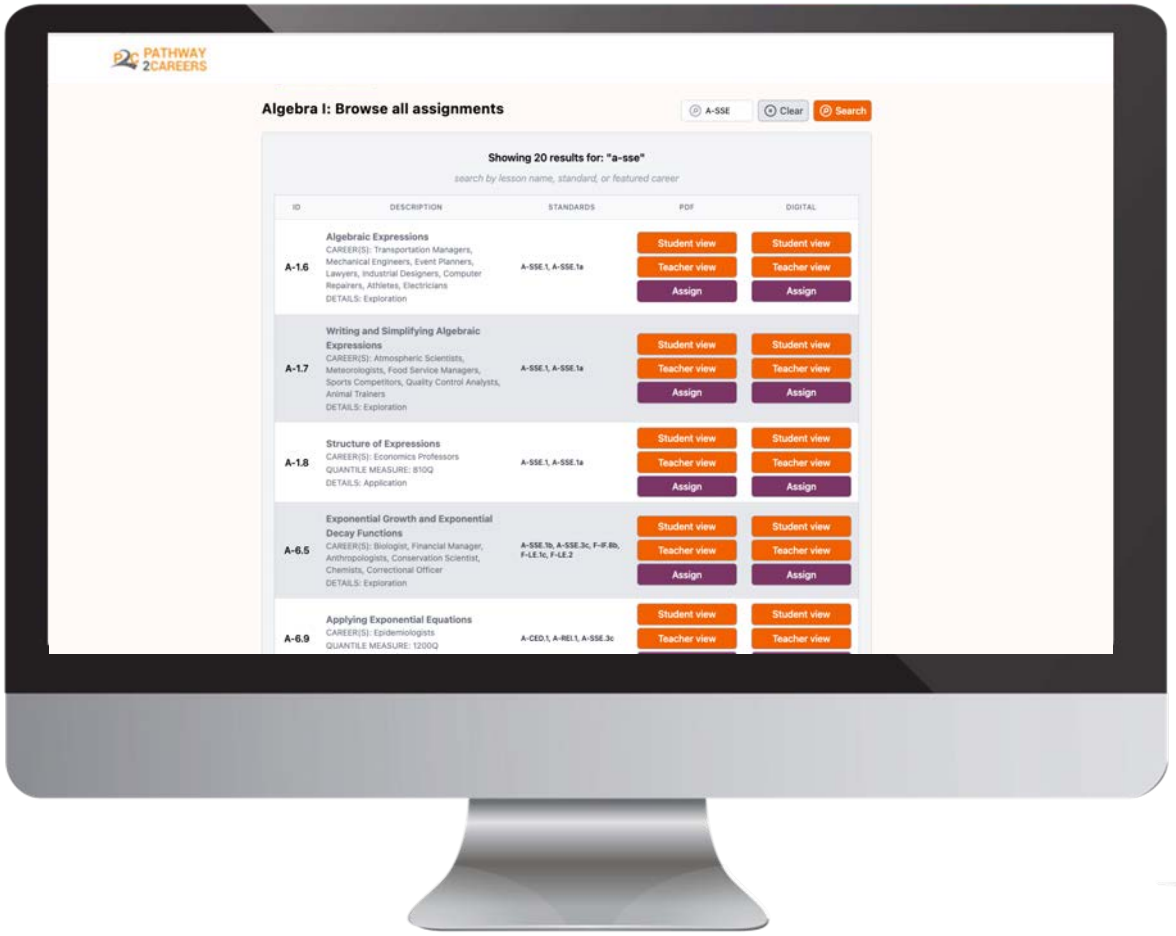
	Title	Type	Mathematical Practices	Career(s)
A-1.1	Real Numbers	Exploration	1, 2, 3	*Multiple*
A-1.2	Quantities and Measurement	Exploration	1, 2, 4	*Multiple*
A-1.3	Applying Dimensional Analysis	Application	4, 6, 7	Dental Laboratory Technicians
A-1.4	Modeling with Quantities	Application	1, 2, 4	Terrazzo Workers and Finishers
A-1.5	Precision and Accuracy	Application	1, 2, 4	Environmental Science And Protection Technicians
A-1.6	Algebraic Expressions	Exploration	1, 2, 7	*Multiple*
A-1.7	Writing and Simplifying Algebraic Expressions	Exploration	2, 4, 7	*Multiple*
A-1.8	Structure of Expressions	Application	1, 4, 7	Economics Teachers, Postsecondary
A-1-P	Seeing Structure in Expressions	Project (Information Technology)	1, 2, 4, 7	Database Architects

2. Solving Equations

	Title	Type	Mathematical Practices	Career(s)
A-2.1	Solving One- and Two-Step Equations	Exploration	1, 2, 7	*Multiple*
A-2.2	Writing Linear Equations	Application	1, 2, 4	Credit Counselors
A-2.3	Solve Multi-Step Equations	Exploration	1, 2, 7	*Multiple*
A-2.4	Solving Linear Equations with a Variable on One Side	Application	1, 2, 4	Veterinarians
A-2.5	Solving Linear Equations with a Variable on Both Sides	Application	1, 4, 5	Bookkeeping, Accounting, and Auditing Clerks
A-2.6	Introduction to Literal Equations and Formulas	Exploration	2, 7, 8	*Multiple*

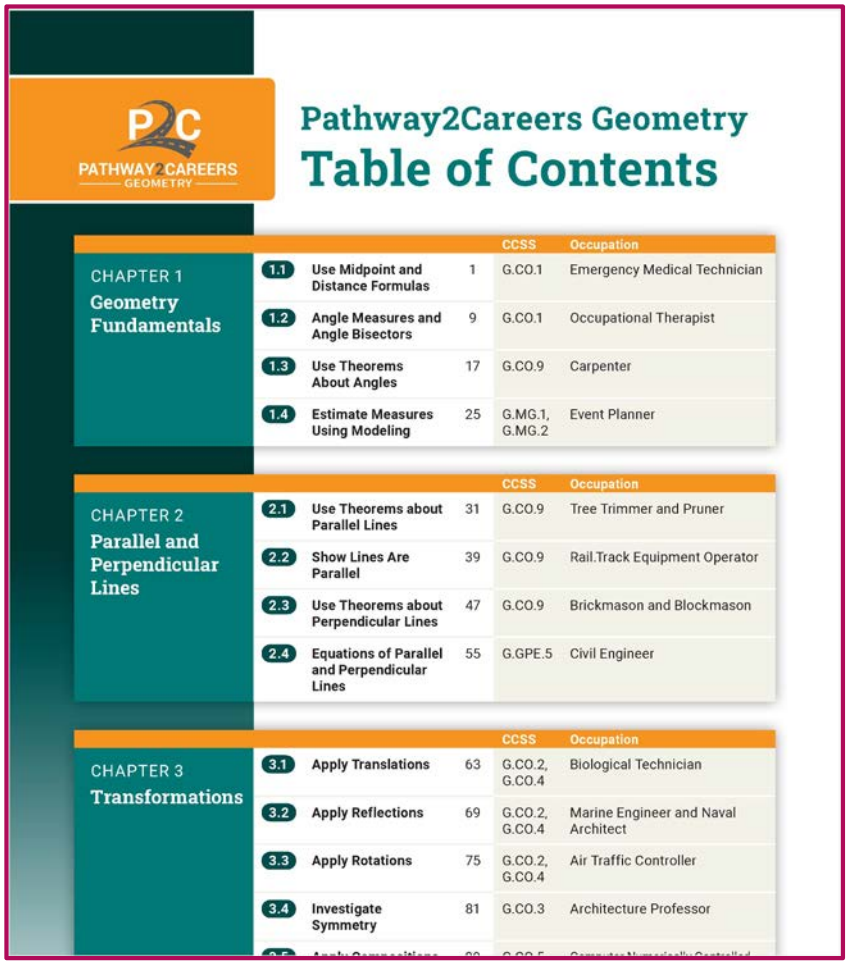
P2C Math Curriculum

- Aligned with Specific State Standards + Common Core State Standards.
- Standards are clearly identified in every lesson.
- Each skill and concept explored is tracked.



Best Practices & Quality Content

- Written and evaluated by experts in math curriculum development.
- Content is presented using well-established methods and best practices in math instruction.



PATHWAY2CAREERS GEOMETRY

Pathway2Careers Geometry Table of Contents

				CCSS	Occupation
CHAPTER 1 Geometry Fundamentals	1.1	Use Midpoint and Distance Formulas	1	G.CO.1	Emergency Medical Technician
	1.2	Angle Measures and Angle Bisectors	9	G.CO.1	Occupational Therapist
	1.3	Use Theorems About Angles	17	G.CO.9	Carpenter
	1.4	Estimate Measures Using Modeling	25	G.MG.1, G.MG.2	Event Planner
CHAPTER 2 Parallel and Perpendicular Lines	2.1	Use Theorems about Parallel Lines	31	G.CO.9	Tree Trimmer and Pruner
	2.2	Show Lines Are Parallel	39	G.CO.9	Rail.Track Equipment Operator
	2.3	Use Theorems about Perpendicular Lines	47	G.CO.9	Brickmason and Blockmason
	2.4	Equations of Parallel and Perpendicular Lines	55	G.GPE.5	Civil Engineer
CHAPTER 3 Transformations	3.1	Apply Translations	63	G.CO.2, G.CO.4	Biological Technician
	3.2	Apply Reflections	69	G.CO.2, G.CO.4	Marine Engineer and Naval Architect
	3.3	Apply Rotations	75	G.CO.2, G.CO.4	Air Traffic Controller
	3.4	Investigate Symmetry	81	G.CO.3	Architecture Professor

Lessons include:

- Job Duties and Responsibilities
- Education Requirements
- Types of Employers
- Career Cluster and Pathway
- Labor Market Data (wage and demand projections)
- Occupation-Related Math Concepts
- Common Work Tasks

LESSON 10

Volume of Cylinders, Cones, and Spheres

CAREER SPOTLIGHT: Agricultural Engineer

Occupation Description

Agricultural engineers work on the storage and processing of agricultural products. They use computer programs to solve problems and design various systems, structures, and facilities. Their work can involve pollution and environmental issues. They work in various fields of farming, such as aquaculture, forestry, and food processing.

This career is relevant to New Mexico as agricultural engineers are employed in the industry sector of sustainable agriculture and value-added agriculture.

Agricultural engineers who solve design problems involving structure will need to understand and apply concepts involving volume.

Education

Agricultural engineers need a bachelor's degree, often in agricultural engineering or biological engineering. Students study advanced calculus, physics, biology, and chemistry.

Potential Employers

Agricultural engineers held about 2,600 jobs in 2018. The largest employers of agricultural engineers were as follows:

Crop production	31%
Federal government, excluding postal service	13%
Colleges, universities, and professional schools; state	10%
Management, scientific, and technical consulting services	8%
Engineering services	4%

Watch a Video about Agricultural Engineers: https://www.bls.gov/ooh/architecture-and-engineering/agricultural-engineers.htm

Career Cluster
Agriculture, Engineering, Food and Natural Resources

Career Pathway
Power, Structure and Technical Systems

Career Outlook
Salary Projections:
- Low-End Salary, $46,500
  Median Salary, $77,110
  High-End Salary, $116,850
- Jobs in 2018: 2,600
- Job Projections for 2028: 2,800 (increase of 8%)

Geometry Concepts
- Apply volume of solids.
- Apply concepts of density.
- Apply geometric methods to solve design problems.

Is this a good career for me?
Agricultural engineers tend to:
- Use computers to design equipment, systems, or structures
- Modify factors that affect production
- Test equipment
- Oversee construction and production operations

NS4ed™ Pathway2Careers™ 2018 Trademark NS4ed, LLC

See appendix for more detail

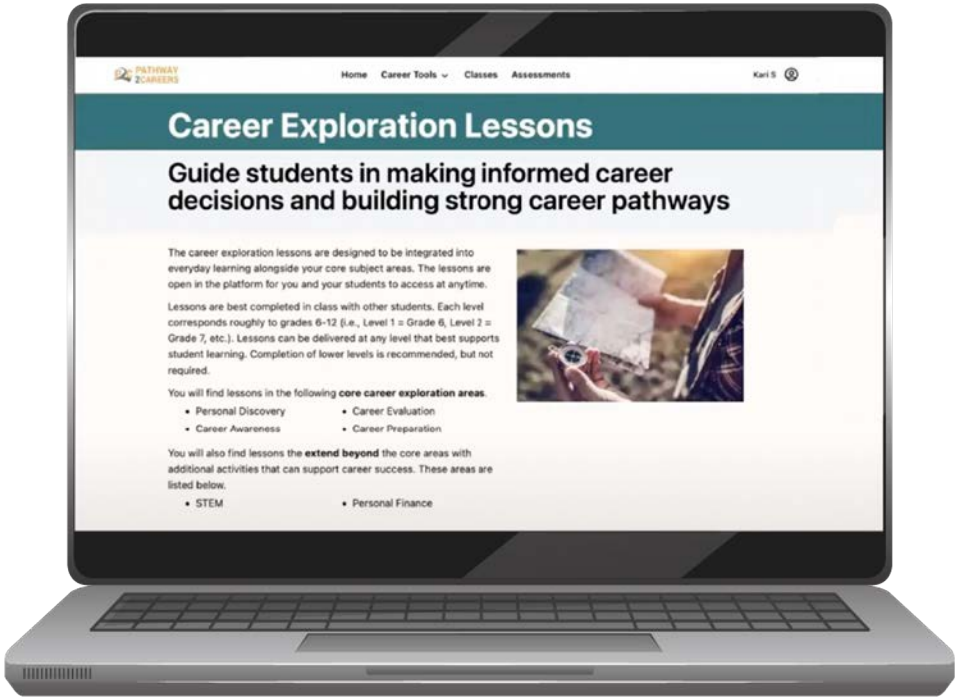
Product Spotlight

P2C Career Explorer

P2C Career Explorer

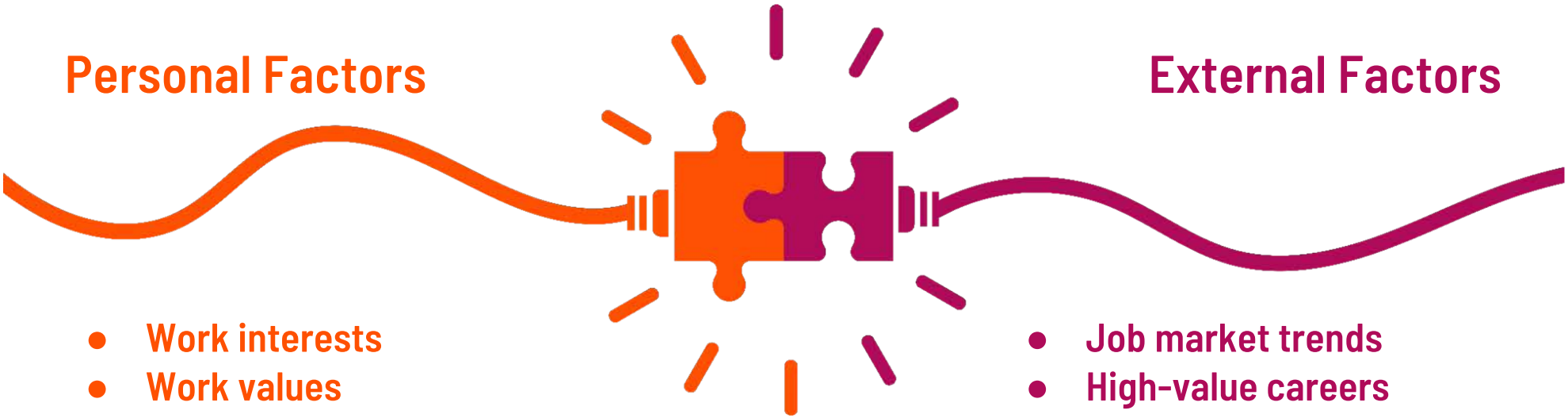
How do we...

- scaffold career exploration so that students are learning the right information at the right grade level?
- put that model in the hands of all educators?



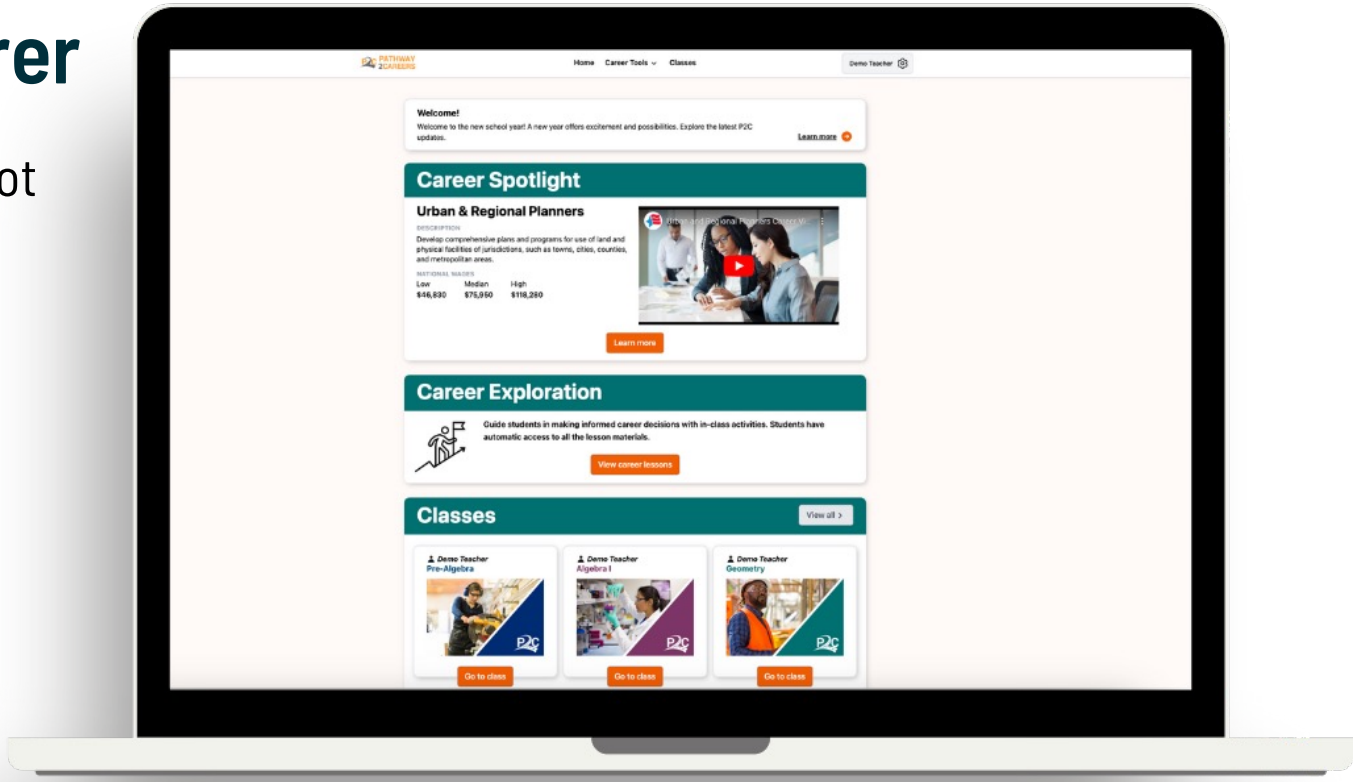
P2C Career Explorer

Connects personal factors to external factors so students can make **informed career decisions.**



P2C Career Explorer

- Career exploration is not a one-time event.
- It is fully integrated within the standards-aligned content.



The Architecture of Career Exploration

Lessons span 7 grades

- Grades 6–12
- 10 lessons per grade
- 70 total lessons

Multiple subject integration

- English language arts
- Mathematics
- Science
- Social Studies
- Physical Education

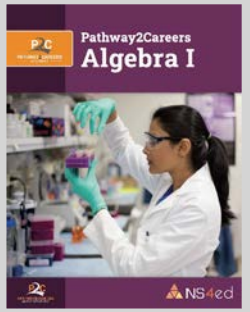
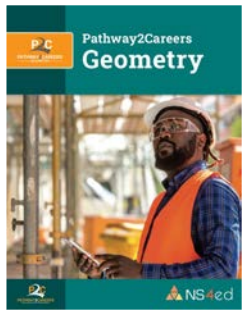
Dual learning objectives

- Career exploration objectives
- Subject-specific objectives

WHO does P2C work for?

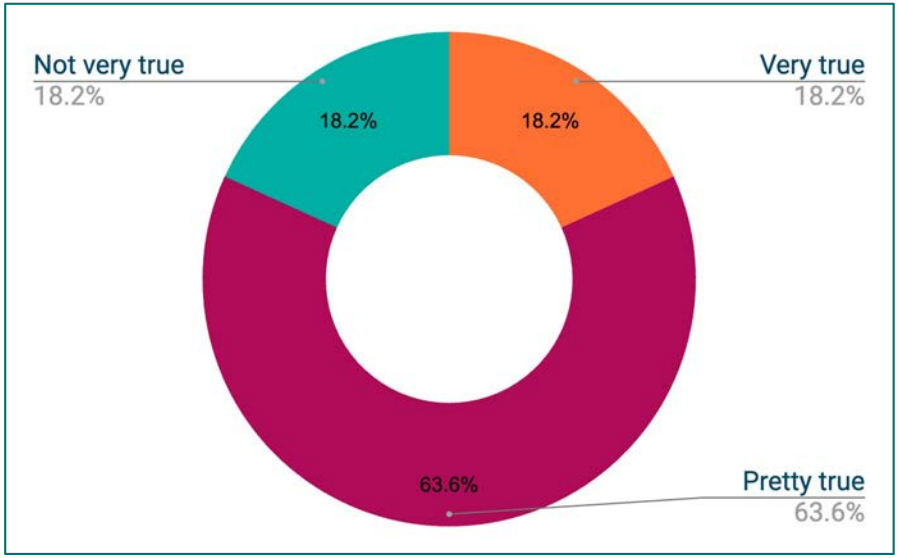
Efficacy & Testimonials

Positive results emerge as New Mexico usage grows

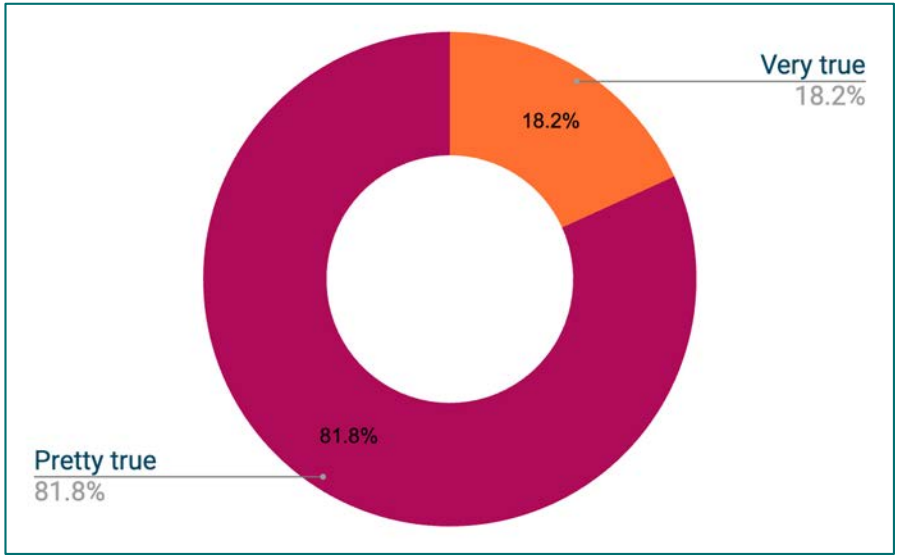
Course	Number of Students	State Pass Rate	P2C Pass Rate	P2C Course
Algebra 1	1,184	76.31	88.94%	
Geometry	987	79.45%	88.65%	

With extended P2C use, surveys show interest in math and career exploration increases.

Students' interest in math increased – 1st survey



Students' interest in math increased – 2nd survey



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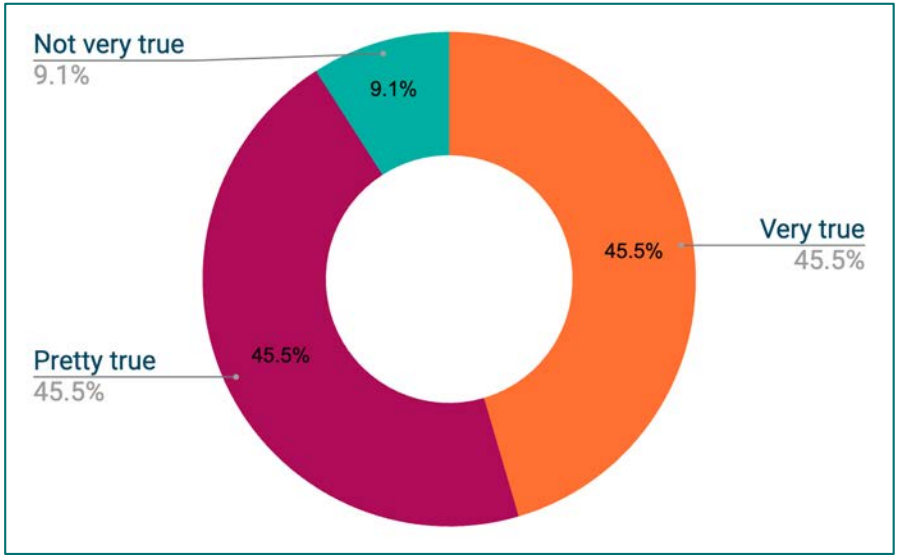
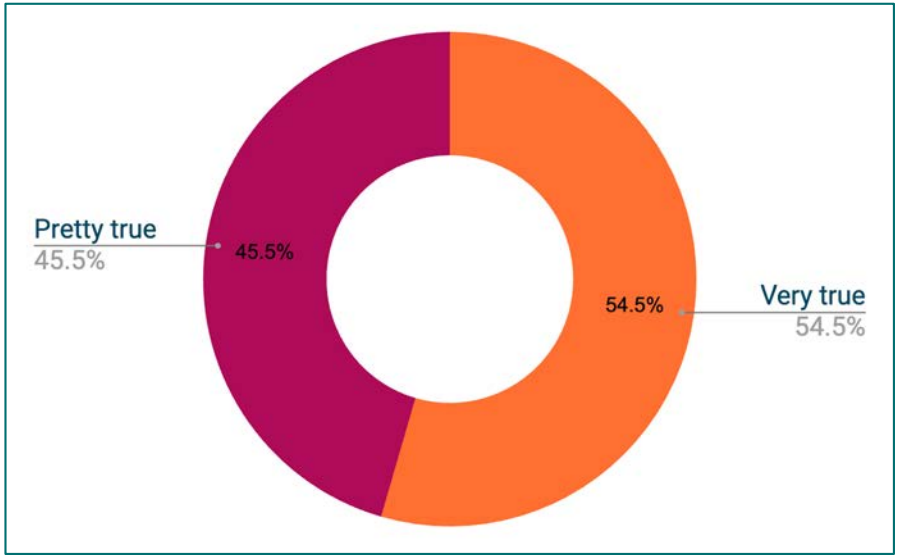


Students' interest in career exploration increased – 2nd survey



Appendix C

P2C Math: Anatomy of a lesson

P2C Math Curriculum Includes...

- Information that helps students connect with the career examples
- Student exposure to viable occupations, which can encourage:
  - Awareness of a wide range of high-value occupations in various career fields
  - Informed career decisions
  - Interest in additional career exploration

LESSON 10

Volume of Cylinders, Cones, and Spheres

CAREER SPOTLIGHT: Agricultural Engineer

Occupation Description

Agricultural engineers work on the storage and processing of agricultural products. They use computer programs to solve problems and design various systems, structures, and facilities. Their work can involve pollution and environmental issues. They work in various fields of farming, such as aquaculture, forestry, and food processing.

This career is relevant to New Mexico as agricultural engineers are employed in the industry sector of sustainable agriculture and value-added agriculture.

Agricultural engineers who solve design problems involving structure will need to understand and apply concepts involving volume.

Education

Agricultural engineers need a bachelor's degree, often in agricultural engineering or biological engineering. Students study advanced calculus, physics, biology, and chemistry.

Potential Employers

Agricultural engineers held about 2,600 jobs in 2018. The largest employers of agricultural engineers were as follows:

Crop production	31%
Federal government, excluding postal service	13%
Colleges, universities, and professional schools; state	10%
Management, scientific, and technical consulting services	8%
Engineering services	4%

Watch a Video about Agricultural Engineers:
https://www.bls.gov/ooh/architecture-and-engineering/agricultural-engineers.htm

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Career Cluster

Agriculture, Engineering, Food and Natural Resources

Career Pathway

Power, Structure and Technical Systems

Career Outlook

Salary Projections:

- Low-End Salary, $46,500
  Median Salary, $77,110
  High-End Salary, $116,850
- Jobs in 2018: 2,600
- Job Projections for 2028: 2,800 (increase of 8%)

Geometry Concepts

- Apply volume of solids.
- Apply concepts of density.
- Apply geometric methods to solve design problems.

Is this a good career for me?

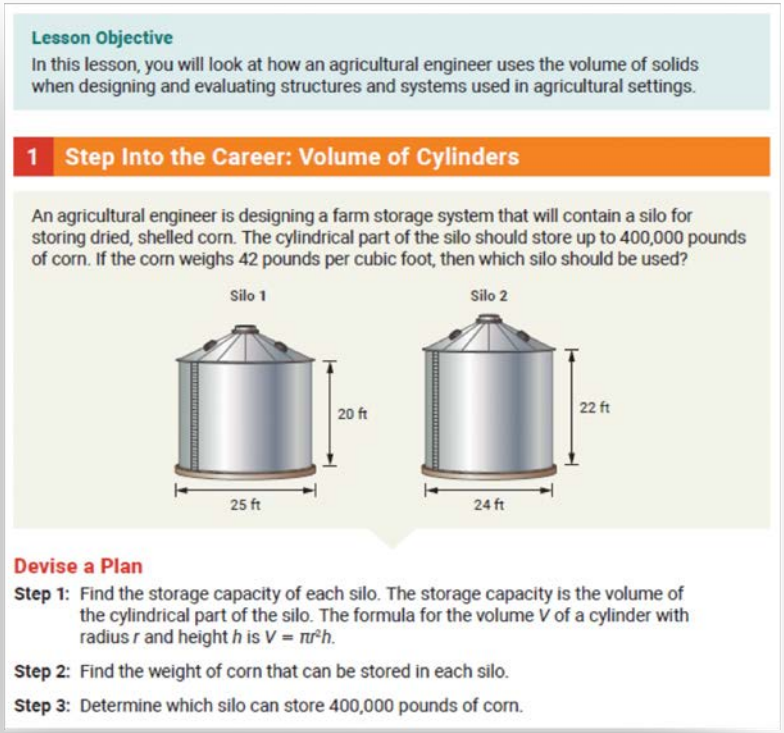
Agricultural engineers tend to:

- Use computers to design equipment, systems, or structures
- Modify factors that affect production
- Test equipment
- Oversee construction and production operations

1

P2C Lessons Will...

- Show **"Math at Work"** as students progress
- Target concepts that are applied to several authentic work tasks
- Provide examples so students learn how the specific algebra or geometry concepts are relevant to that occupation



Lesson Objective

In this lesson, you will look at how an agricultural engineer uses the volume of solids when designing and evaluating structures and systems used in agricultural settings.

1 Step Into the Career: Volume of Cylinders

An agricultural engineer is designing a farm storage system that will contain a silo for storing dried, shelled corn. The cylindrical part of the silo should store up to 400,000 pounds of corn. If the corn weighs 42 pounds per cubic foot, then which silo should be used?

Devise a Plan

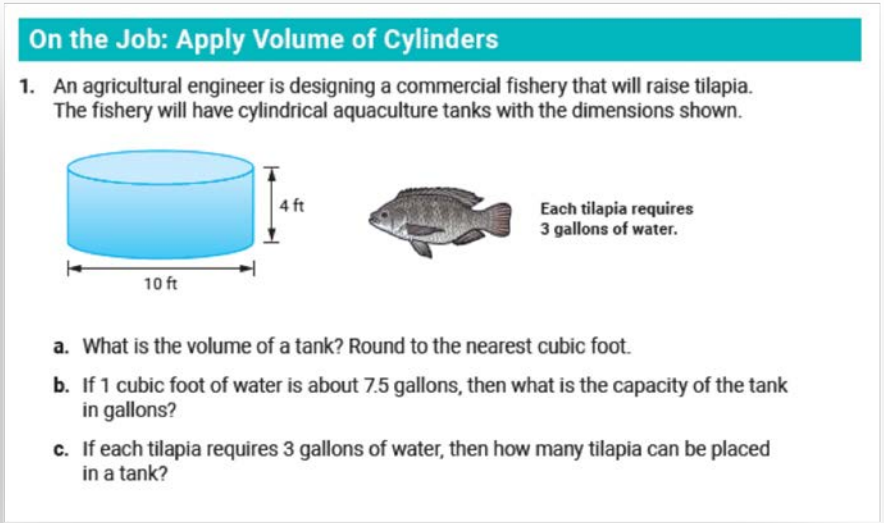
Step 1: Find the storage capacity of each silo. The storage capacity is the volume of the cylindrical part of the silo. The formula for the volume V of a cylinder with radius r and height h is $V = \pi r^2 h$.

Step 2: Find the weight of corn that can be stored in each silo.

Step 3: Determine which silo can store 400,000 pounds of corn.

P2C Lessons Will...

- Provide opportunities to practice using algebra and geometry in the context of the career.
- Build upon career examples presented earlier in the lesson
- Can be completed in class or during independent study



On the Job: Apply Volume of Cylinders

1. An agricultural engineer is designing a commercial fishery that will raise tilapia. The fishery will have cylindrical aquaculture tanks with the dimensions shown.

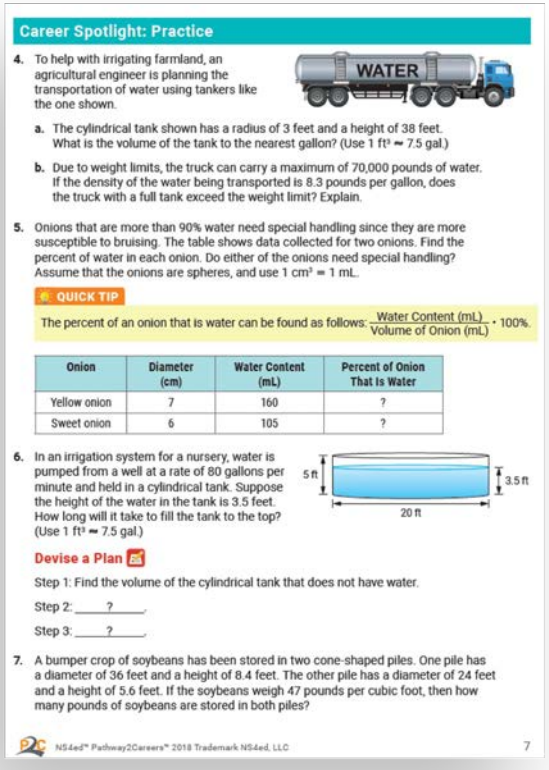
   a. What is the volume of a tank? Round to the nearest cubic foot.

   b. If 1 cubic foot of water is about 7.5 gallons, then what is the capacity of the tank in gallons?

   c. If each tilapia requires 3 gallons of water, then how many tilapia can be placed in a tank?

P2C Lessons Will...

- Immerse students in the career with additional practice
- Provide students the opportunity to practice using the lesson-specific algebra or geometry sills in real, work-related problems and exercises



Career Spotlight: Practice

4. To help with irrigating farmland, an agricultural engineer is planning the transportation of water using tankers like the one shown.

a. The cylindrical tank shown has a radius of 3 feet and a height of 38 feet. What is the volume of the tank to the nearest gallon? (Use 1 $ft^3 \approx 7.5$ gal.)

b. Due to weight limits, the truck can carry a maximum of 70,000 pounds of water. If the density of the water being transported is 8.3 pounds per gallon, does the truck with a full tank exceed the weight limit? Explain.

5. Onions that are more than 90% water need special handling since they are more susceptible to bruising. The table shows data collected for two onions. Find the percent of water in each onion. Do either of the onions need special handling? Assume that the onions are spheres, and use 1 $cm^3 = 1$ mL.

QUICK TIP

The percent of an onion that is water can be found as follows: $\frac{\text{Water Content (mL)}}{\text{Volume of Onion (mL)}} \cdot 100\%$.

Onion	Diameter (cm)	Water Content (mL)	Percent of Onion That Is Water
Yellow onion	7	160	?
Sweet onion	6	105	?

6. In an irrigation system for a nursery, water is pumped from a well at a rate of 80 gallons per minute and held in a cylindrical tank. Suppose the height of the water in the tank is 3.5 feet. How long will it take to fill the tank to the top? (Use 1 $ft^3 \approx 7.5$ gal.)

Devise a Plan

Step 1: Find the volume of the cylindrical tank that does not have water.

Step 2: ____?____.

Step 3: ____?____.

7. A bumper crop of soybeans has been stored in two cone-shaped piles. One pile has a diameter of 36 feet and a height of 8.4 feet. The other pile has a diameter of 24 feet and a height of 5.6 feet. If the soybeans weigh 47 pounds per cubic foot, then how many pounds of soybeans are stored in both piles?

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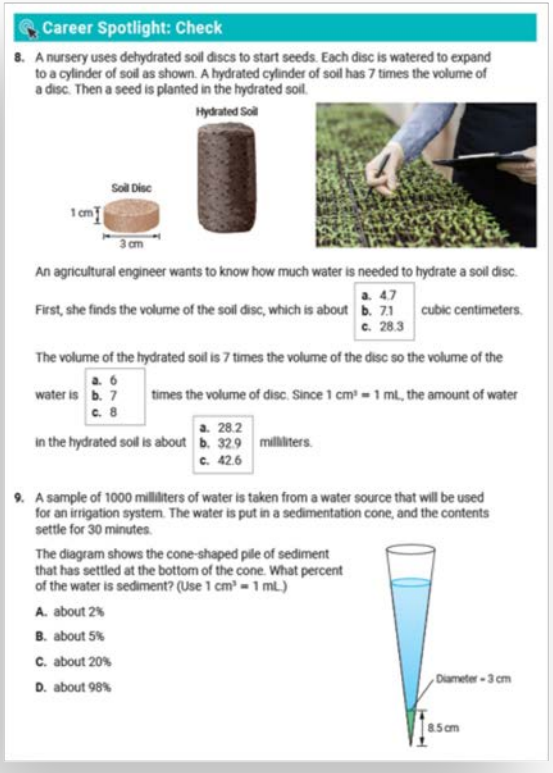
P2C Lessons Will...

- Conclude with a check for students to complete
- A variety of question formats are used to evaluate learning
- Use as a formative assessment to review students' learning and provide feedback



Career Spotlight: Check

8. A nursery uses dehydrated soil discs to start seeds. Each disc is watered to expand to a cylinder of soil as shown. A hydrated cylinder of soil has 7 times the volume of a disc. Then a seed is planted in the hydrated soil.

Hydrated Soil

Soil Disc

1 cm

3 cm

An agricultural engineer wants to know how much water is needed to hydrate a soil disc.

First, she finds the volume of the soil disc, which is about [a. 4.7 / b. 7.1 / c. 28.3] cubic centimeters.

The volume of the hydrated soil is 7 times the volume of the disc so the volume of the water is [a. 6 / b. 7 / c. 8] times the volume of disc. Since 1 cm^3 = 1 mL, the amount of water in the hydrated soil is about [a. 28.2 / b. 32.9 / c. 42.6] milliliters.

9. A sample of 1000 milliliters of water is taken from a water source that will be used for an irrigation system. The water is put in a sedimentation cone, and the contents settle for 30 minutes.

The diagram shows the cone-shaped pile of sediment that has settled at the bottom of the cone. What percent of the water is sediment? (Use 1 cm^3 = 1 mL.)

A. about 2%

B. about 5%

C. about 20%

D. about 98%

Diameter = 3 cm

8.5 cm

P2C Lesson Content Preview

LESSON 2.4

Literal Equations and Formulas

CAREER SPOTLIGHT: Electrician

Occupation Description

Electricians install, maintain, and repair electrical power, communications, lighting, and control systems in homes, businesses, and factories.

Electricians read blueprints, which include technical diagrams of electrical systems that show the location of circuits, outlets, and other equipment. They use different types of hand and power tools, such as conduit benders, to run and protect wiring.

Education

A high school diploma or equivalent is required to become an electrician.

Some electricians start out by attending a technical school. Many technical schools offer programs related to circuitry, safety practices, and basic electrical information. Graduates of these programs usually receive credit toward their apprenticeship.

Potential Employers

The largest employers of electricians are as follows:

Electrical contractors and other wiring installation contractors	66%
Manufacturing	7%
Self-employed workers	6%
Government	3%
Employment services	3%

Watch a video about electricians:
https://cdn.careeronestop.org/OccVids/OccupationVideos/47-2111.00.mp4

Photo credit: BridShutterB/Shutterstock.com

Career Cluster
Architecture & Construction

Career Pathway
Construction

Career Outlook
- Salary Projections:
  Low-End Salary, $33,410
  Median Salary, $56,180
  High-End Salary, $96,580
- Jobs in 2018: 715,400
- Job Projections for 2028: 789,500 (increase of 10%)

Algebra Concepts
- Solve literal equations to highlight a quantity of interest.
- Use units to guide the solution of multi-step problems.

Is this a good career for me?
Electricians:
- Read blueprints or technical diagrams
- Install and maintain wiring, control, and lighting systems
- Inspect electrical components
- Identify electrical problems using a variety of testing devices
- Repair or replace wiring, equipment, or fixtures

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Lesson Objective
In this lesson, you will look at how equations and unit analysis can help an electrician in everyday work and business tasks.

Formulas and Units for Electricity
In this lesson, you will use various formulas for electricity with the units given here.

Ohm's law: $V = IR$

Electrical power: $P = IV$

Total resistance in a series circuit: $R_{total} = R_1 + R_2 + R_3 + ... + R_n$

Total voltage in a series: $V_{total} = V_1 + V_2 + V_3 + ... + V_n$

Resistance in a wire: $R = \frac{\rho L}{A}$

V = voltage in volts (V)
I = current in the wire in amperes (A)
R = resistance in ohms (Ω)
P = power in watts (W)
ρ = resistivity in ohm meters (Ω-m)
L = length of the wire in meters (m)
A = cross-sectional area of the wire in meters squared (m^2)

Wire Gauge Sizes
In the electrical industry, wires come in gauge sizes. An electrician can use a table, such as the one shown, to determine the wire gauge size from the cross-sectional area of a wire.

Wire Gauge Sizes

Cross-Sectional Wire Area (mm^2)	Wire Gauge Size
0.823	18
1.31	16
2.08	14
3.31	12
5.26	10
8.37	8

P2C Lesson Content Preview

1 Step Into the Career: Solving a Literal Equation

An electrician is going to install a new electric winch on a boat, and she needs to calculate what size wire to use to hook up the winch to the battery.

According to the winch operating instructions, she must make sure it will receive a steady supply of 100 amperes of electric current.

She needs 4 meters of wire. The wire is part of a circuit. To calculate the wire size, she can assume that 10% of the total resistance in the circuit will go to the wires.

The battery voltage is 12 volts. She will use copper wire, which has a resistivity of 1.7×10^{-8} ohm-meters.

What size wire will she need? Use the table of wire gauge sizes on page 78 to answer the question.

Devise a Plan

The equations that the electrician will use in this situation are $V = IR$ and $R = \frac{\rho L}{A}$.

Step 1: Identify the known values and what needs to be found.

Step 2: Solve each *literal equation* for a quantity of interest.

A **literal equation** is an equation that has two or more variables, which can have letters instead of numbers for constants. A formula is an example of a literal equation.

Step 3: Use the known values to determine the unknown values to find the answer.

Walk Through the Solution

Step 1: Identify the known values and what needs to be found.

To determine the wire size, the electrician needs to find the area A of the wire. In the equation $R = \frac{\rho L}{A}$, she knows the resistivity $\rho = 1.7 \times 10^{-8}$ Ω-m and the length $L = 4$ m of the wire. She does not know the resistance R in the wire.

To find the resistance R, she can use Ohm's law, $V = IR$. She knows the voltage $V = 12$ V and current $I = 100$ A.

Note that this R is the resistance in the entire circuit. To find the resistance in the wire, multiply by 0.1.

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On the Job: Apply Solving a Literal Equation

1. Aluminum wires are often used in airplanes because they are lighter than copper.

   a. Show how to use the equation $R = \frac{\rho L}{A}$ and the formula for the area of a circle to derive the following equation for resistance.

$$R = \frac{4L\rho}{\pi d^2}$$

   b. What is the resistance of an aluminum wire that is 6.7 meters long with a diameter of 1.5 millimeters if the resistivity of aluminum is 3.2×10^{-8} Ω-m?

2 Step Into the Career: Combining Equations

An electrician is helping a startup company design a new drone. The company asks the electrician to determine how much lighter the drone would be if they use aluminum wire instead of copper wire.

The resistivity of copper is 1.7×10^{-8} ohm-meters, and the resistivity of aluminum is 3.2×10^{-8} ohm-meters.

If 5.4 meters of 18 gauge copper wire is needed, what gauge of aluminum wire of the same length has about the same resistance? Which length of wire is lighter and by how much? The density of copper is 8.9 grams per cubic centimeters, and the density of aluminum is 2.7 grams per cubic centimeters.

Devise a Plan

Use the equation $R = \frac{\rho L}{A}$. For the volume and mass of the wire, assume that the wire can be modeled by a cylinder, so volume $= A \cdot L$, where A is the cross-sectional area of the wire and L is the length, and density $= \frac{\text{mass}}{\text{volume}}$.

Step 1: Find the cross-sectional area for 18 gauge wire from the table of wire gauge sizes on page 78.

Step 2: Identify the known values and what needs to be found to answer the first question.

Step 3: Use the known values and appropriate equation to determine the unknown values to find the answer.

Step 4: Identify the known values and what needs to be found to answer the second question.

Step 5: Use the formulas for volume and density to write an equation for mass. Then use the known values to find the mass of each wire.

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P2C Lesson Content Preview

On the Job: Apply Solving a Literal Equation

3. An electrician has been offered a contract opportunity with a band on tour to set up each of its concerts. He will be paid a base amount for each month plus an additional amount for each concert that he sets up during that month. There is a dispute about the amount for each concert, but the electrician has kept invoices from past payments.

   a. Write a literal equation to represent this situation. Let T be the total amount the electrician gets paid, C be the amount he gets paid for each concert, n be the number of concerts he sets up, and B be the base amount.

   b. Solve the equation for C.

   c. Records show that the electrician is paid a base amount of $2000 for each month. Last month, he set up 8 concerts and was paid $5200. What is the amount the electrician is paid for each concert?

Career Spotlight: Practice

4. An airplane is 73 meters long. An electrician runs a 12 gauge copper wire from the front to the back of the plane. A 12 gauge wire has a cross-sectional area of 3.31 square millimeters.

   a. What is the resistance of the 12 gauge copper wire?

   b. What is the resistance if the wire is 12 gauge aluminum?

QUICK TIP

To help visualize which numbers go in which equation, make a sketch of two wires, and label each wire with the known values and the unknowns.

7. An electrician is helping a rock band set up for a concert and connects three sound amplifiers in a series. One amplifier draws 120 volts, a second draws 100 volts, and a third draws 80 volts. The wires in the system draw 10 volts. The current in the system is a steady 11 amperes.

   a. Determine an equation to find the overall resistance in the system. What is the total resistance?

   b. What is the resistance of the second amplifier?

QUICK TIP

Write down the values that are known and what you do not know. Then find and write down the equations that you will need to solve.

Career Spotlight: Check

8. An electrician is wiring an airplane with 171 miles of aluminum wire. How many meters of wire is that? Use 1.61 km = 1 mi.

   A. about 275 m

   B. about 2750 m

   C. about 2.75×10^5 m

   D. about 2.75×10^8 m

9. An electrician connects three resistors in a series. The total voltage can be represented by the literal equation $V = I(R_1 + R_2 + R_3)$.

   a. Solve the literal equation for R_3.

   b. The total voltage is 24 volts, the current is 2 amperes, the resistance of the first resistor is 3 ohms, and the resistance of the second resistor is 4 ohms. What is the resistance of the third resistor?

10. An electrician is calculating the power, current, resistance, and voltage in a number of circuits using Ohm's law, $V = IR$.

    Match the quantities so they satisfy Ohm's law.

	$R = 4\ \Omega$	$R = 3\ \Omega$	$I = 3$ A	$I = 2$ A
$V = 8$ V, $R = 4\ \Omega$	□	□	□	□
$V = 6$ V, $R = 3\ \Omega$	□	□	□	□
$V = 12$ V, $I = 4$ A	□	□	□	□
$V = 12$ V, $I = 3$ A	□	□	□	□

P2C Lesson Content Preview

LESSON 2.4

Literal Equations and Formulas

Common Core State Standards

A-CED.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.

N.Q.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas.

Mathematical Practices 4, 6, 7

CAREER SPOTLIGHT: Electrician

Electricians use math and science in making sure that they have the correct equipment and meet specifications. They must make sure that electrical wiring, equipment, and fixtures meet safety codes. They need to be knowledgeable about various testing tools and measuring devices.

- Discuss with students the kind of work electricians do by reading the Career Spotlight together.
- Find local vocational schools and colleges with an electrical training program to share with students.
- Research local companies that employ electricians or independent contractors, and ask what electricians do.

Video: Electricians

Have students watch this video, which describes the types of projects electricians might work on.

Lesson Objective

In this lesson, you will look at how equations and unit analysis can help an electrician in everyday work and business tasks.

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On the Job: Apply Solving a Literal Equation

Answers

1a. Using the formula for the area of a circle, the cross-sectional area of a wire, is

$A = \pi r^2 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$. Substitute $\frac{\pi d^2}{4}$ for the cross-sectional area in for A.

$$R = \frac{\rho L}{A} = \frac{\rho L}{\left(\frac{\pi d^2}{4}\right)} = \frac{4L\rho}{\pi d^2}$$

1b. 0.121 Ω

Use these questions to check students' understanding.

- In 1a, what relationship between radius and diameter did you use?
- In 1b, did you convert any units? If so, what units did you convert?

2 Step Into the Career: Combining Equations

An electrician is helping a startup company design a new drone. The company asks the electrician to determine how much lighter the drone would be if they use aluminum wire instead of copper wire.

The resistivity of copper is 1.7×10^{-8} ohm-meters, and the resistivity of aluminum is 3.2×10^{-8} ohm-meters.

If 5.4 meters of 18 gauge copper wire is needed, what gauge of aluminum wire of the same length has about the same resistance? Which length of wire is lighter and by how much? The density of copper is 8.9 grams per cubic centimeters, and the density of aluminum is 2.7 grams per cubic centimeters.

Guiding Questions

- In Step 1, how do you determine the cross-sectional area?
- In Step 3, what conversion do you use to convert square millimeters to square meters and vice versa?
- In Step 4, why do you convert the measurement to centimeters?
- In Step 5, what are the densities in grams per cubic meters?

DIFFERENTIATION: ADDITIONAL SUPPORT Some students may benefit from using blank paper instead of lined paper to help them organize the known values and what they need to find. On blank paper, students can organize the data in patterns and see the numbers and letters with less distraction from the lines. Colored pens can also help students separate and classify information to make the algebra easier to understand.

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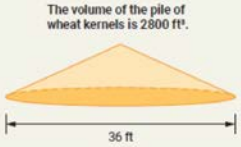
P2C Teacher's Edition Preview

2 Step Into the Career: Volume of Cones

An agricultural engineer designs an area for temporary storage of 2800 cubic feet of harvested wheat kernels. A cone-shaped pile of 2800 cubic feet of wheat kernels will have a diameter of 36 feet. At what minimum height above the ground should the end of the grain auger transporting the wheat be set so that it clears the pile?



Students may not be familiar with a grain auger. A grain auger is a tube with a spiral shaft in the middle that transports grain. This is not to be confused with an auger that is a type of drilling device.

Guiding Questions

- Could the height be determined if only the volume of the pile was given and not the diameter?
- The height and diameter of a pile of wheat must remain in proportion. Suppose the volume of the wheat increases. Will the height of the pile be greater than or less than 8.25 feet? Explain.

ENRICHMENT The shape of a conical pile depends on the material. For wheat, the angle formed by a line from the vertex of the cone to the ground is about 25°. In this example, students can find this angle by calculating $\tan^{-1}\left(\frac{8.25}{18}\right) \approx 25°$. If the grain for this pile is barley, the angle is about 28°. Ask students to determine the height and volume of a pile of barley with diameter 36 feet.

Teaching Support

1 Step Into the Career: Volume of Cylinders

An agricultural engineer is designing a farm storage system that will contain a silo for storing dried, shelled corn. The cylindrical part of the silo should store up to 400,000 pounds of corn. If the corn weighs 42 pounds per cubic foot, then which silo should be used?

Guiding Questions

- In Step 2, how can the number of pounds be found using a proportion?
- In Step 3, will a silo that has a diameter of 26 feet and a height of 20 feet hold the corn?

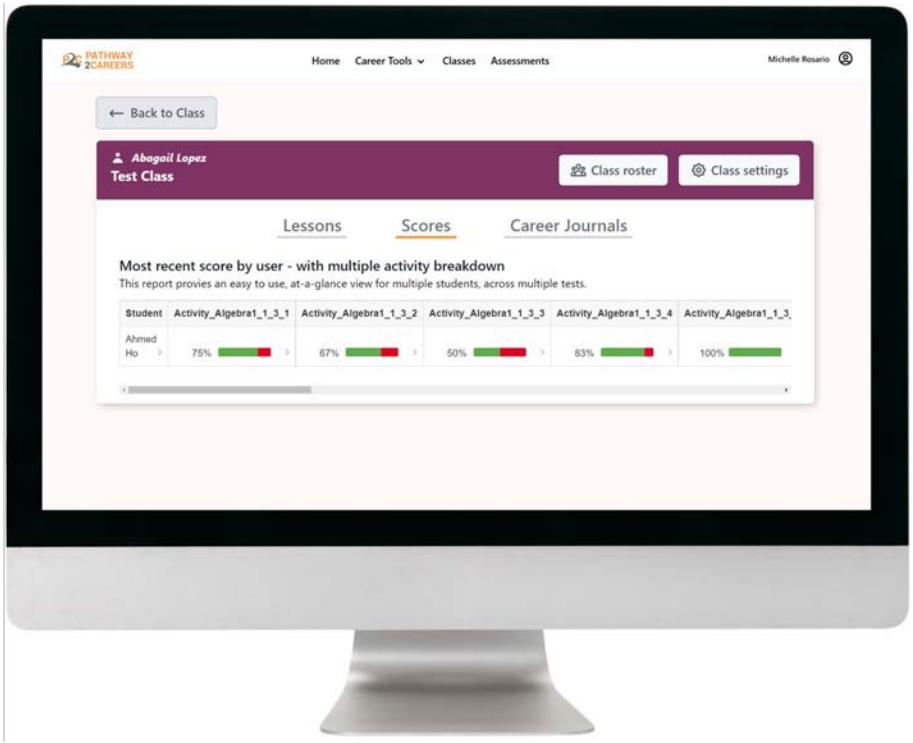
ENRICHMENT In this example, both silos can store 400,000 pounds of corn. Ask students to suggest what other criteria an agricultural engineer could consider in designing a silo. Discuss what considerations could be made about the amount of material needed to build the silos. Remind students that the lateral surface area of a cylinder can be determined by the formula $S = 2\pi rh$, where r is the radius and h is the height. Ask students to determine which silo has the greater lateral surface area.

TECHNOLOGY Challenge students to think about the dimensions of a cylinder that can hold 400,000 pounds of corn with the least amount of lateral surface area. Have students find the volume needed for 400,000 pounds of corn and then ask for an expression for the height h of a cylinder that can hold the corn in terms of radius r. Demonstrate using technology (by graphing or using a spreadsheet) how to determine the radius that results in the minimum lateral surface area.

P2C Reporting Preview

Teacher View

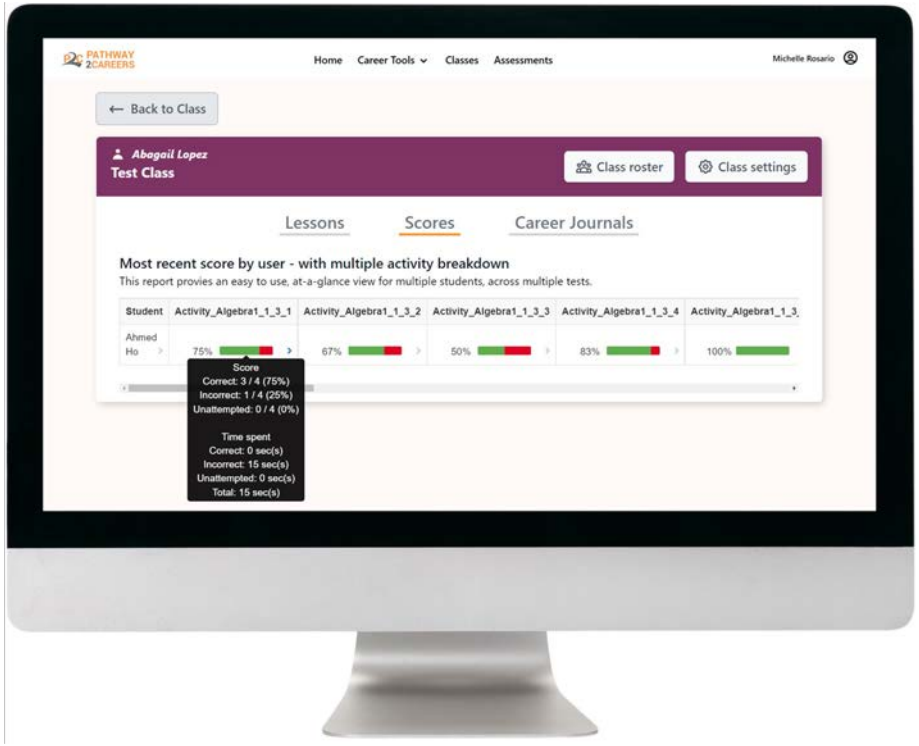
- Class overview



P2C Reporting Preview

Teacher View

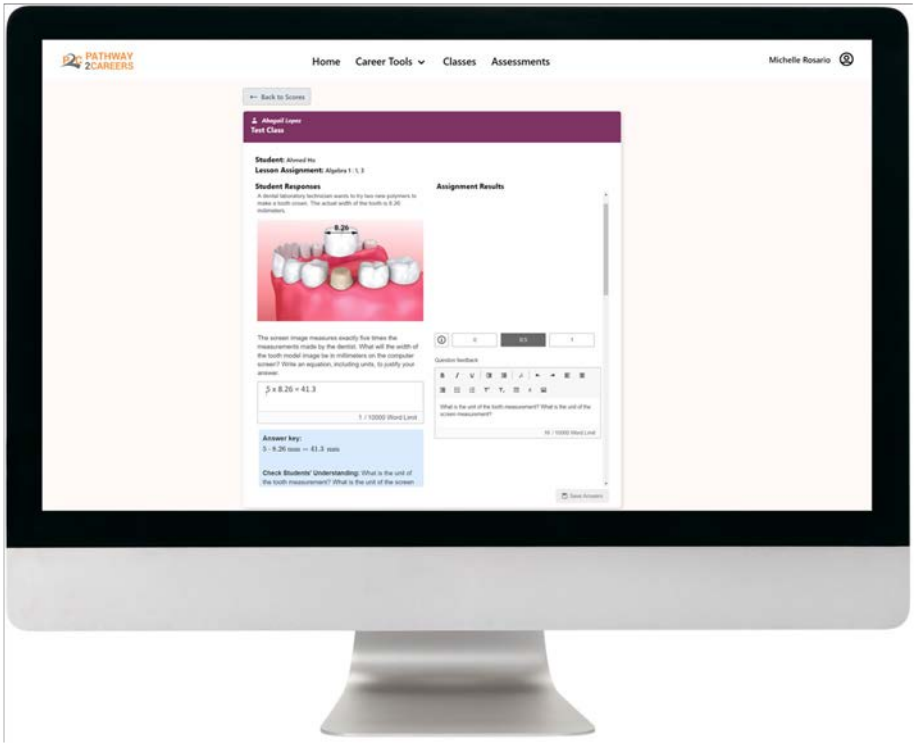
- Overview of whole class
- Hover over the scores to view further details
- Click on the score to see a full detailed report



P2C Reporting Preview

Teacher View

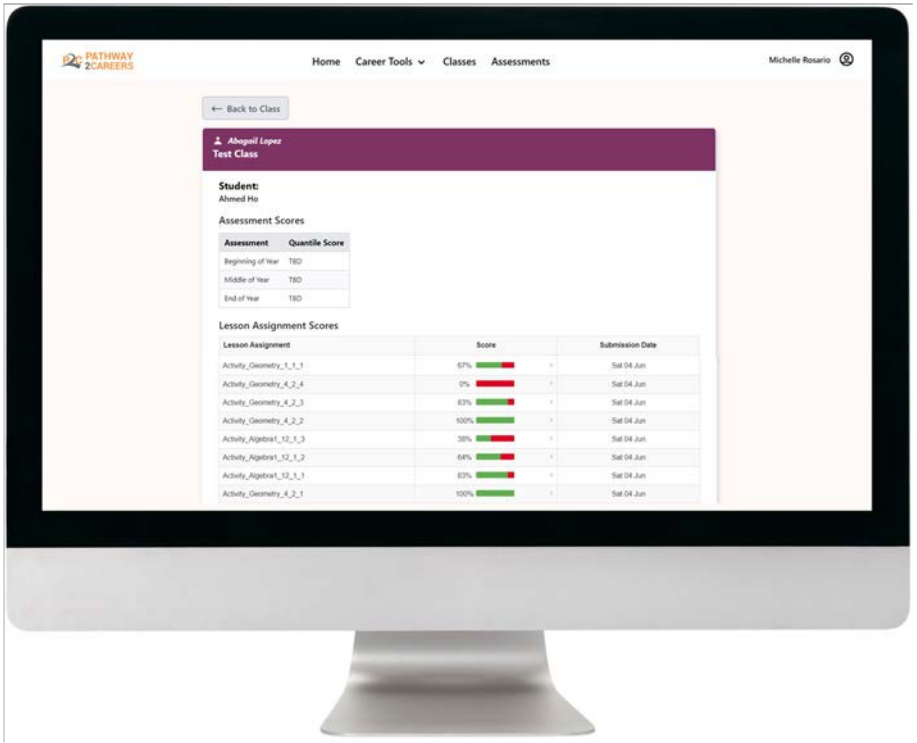
- Student responses on the left with answers and teacher notes in blue
- Rubric-based scoring and feedback on the right



P2C Reporting Preview

Teacher View

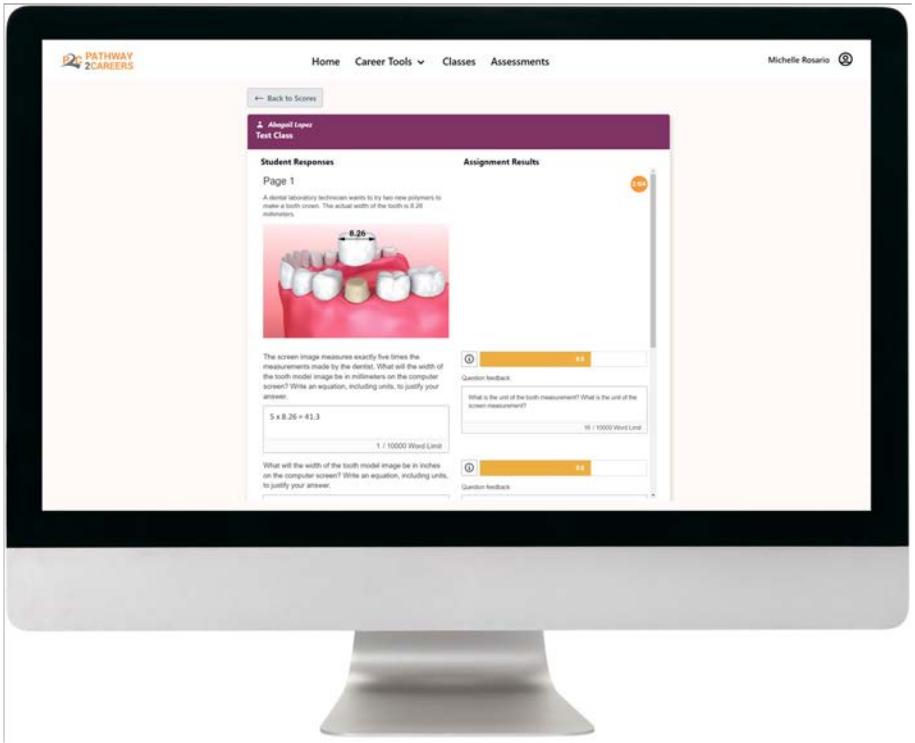
- Student score report
- Click a score for a more detailed report



P2C Reporting Preview

Student View

- Student score report
- Click a score for a more detailed report

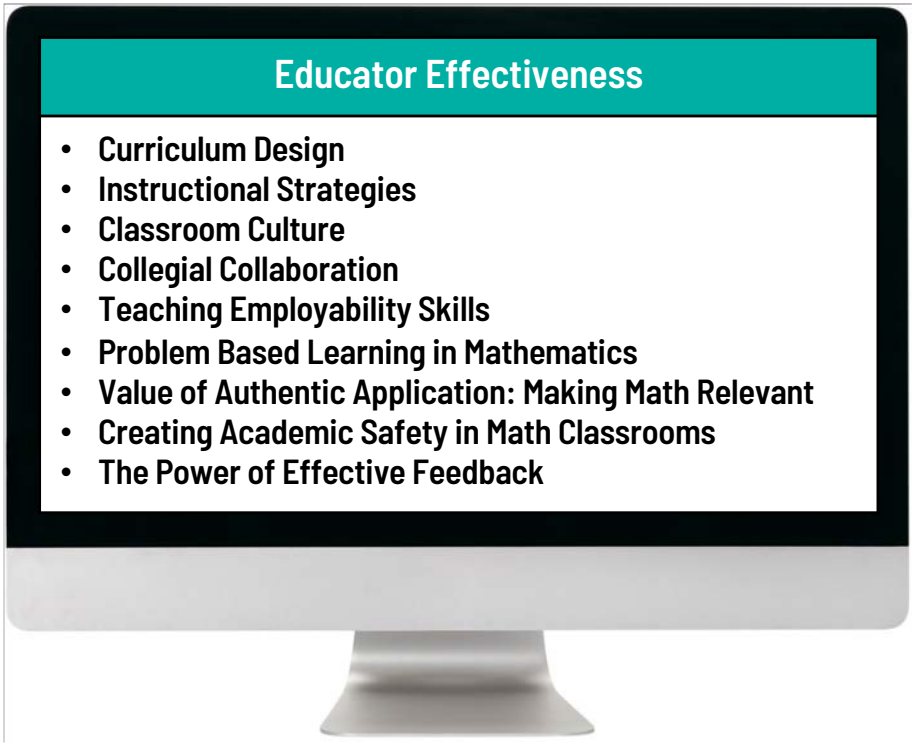


Category: Educator Effectiveness

The Educator Effectiveness category of courses is designed to help educators develop the knowledge and skills they need to be effective in the classroom. The courses cover a wide range of topics. These courses can be taken by educators at all levels, from pre-service teachers to experienced professionals. They offer a valuable opportunity for educators to learn new skills and strategies to improve their teaching practice.

Included in the Online Professional Development for:

- District Level Navigator + CE
- MS & HS Bundles

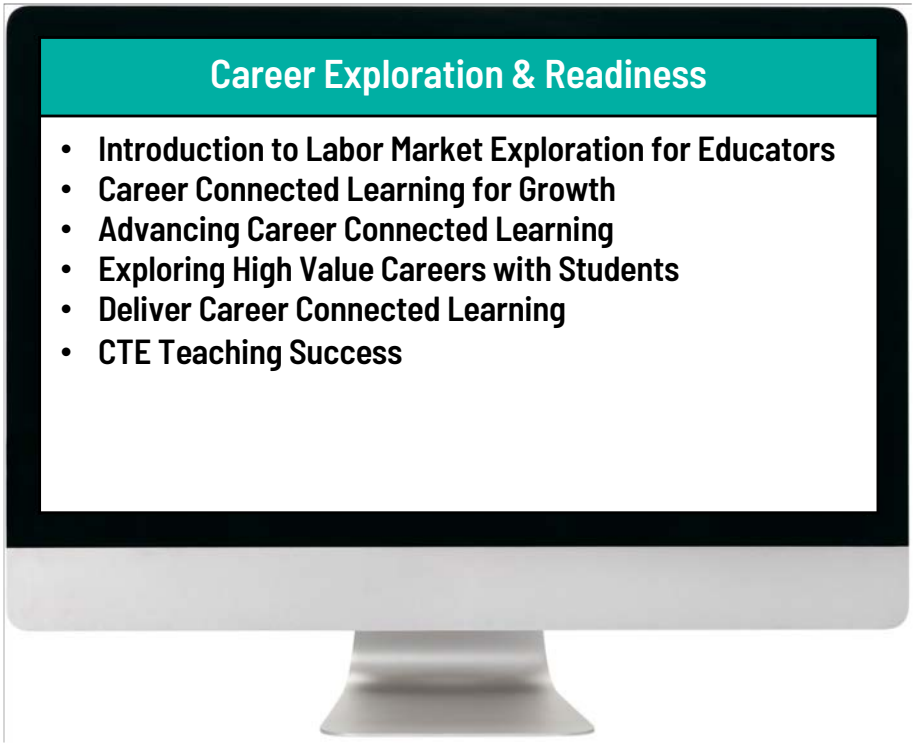


Category: Career Exploration & Readiness

The Career Exploration and Readiness category of courses is designed to help educators prepare students for the workforce by teaching them about the labor market, career options, and the skills they need to be successful. By providing access to the information in these courses, P2C is equipping educators to help students make informed choices about their future careers and prepare for success in the workforce. These courses also aid educators in understanding how to use labor market data to make the best decisions for their districts.

Included in the Online Professional Development for:

- District Level Navigator + CE
- MS & HS Bundles

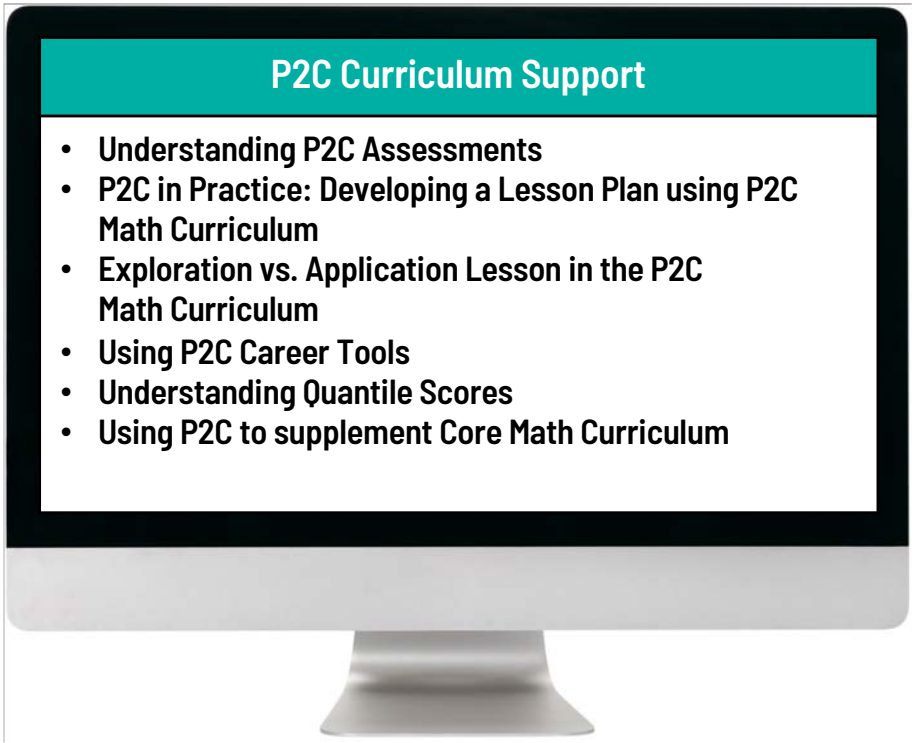


Category: P2C Curriculum Support

The P2C Curriculum Support category of courses is designed to help educators understand and use the Pathway2Careers (P2C) math curriculum. These courses help educators take a deeper dive with P2C as either a supplemental or core curriculum.

Included in the Online Professional Development for:

- MS & HS Bundles



Category: Employability Skills

The **Employability Skills** courses provides learners with an in-depth understanding of each Employability Skill, real-world demonstrations of use, and reflection activities. The United States Department of Education recognizes nine Employability Skills in their Employability Skills Framework. These skills have significant overlap with the Soft Skills identified by the United States Department of Labor.

This category of courses is available as an additional offering with the Navigator + CE Package

PATHWAY 2 CAREERS