Inquiry-Based Learning (IBL)

Moderated by:
Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

https://www2.calstate.edu/impact-of-the-csu/research/stem-net

Speakers

Topaz Wiscons and Stan Yoshinobu, Sacramento State and Cal Poly San Luis Obispo
Examples of IBL in Math

Erik Helgren, Cal State East Bay
The Solar Suitcase Class – A Sustainability and Social Justice Motivated Inquiry Based Learning Class

Marina Shapiro, CSU Bakersfield
California Challenges in STEM Energy Education

Brian Self and Jim Widmann, Cal Poly San Luis Obispo
Inquiry-Based Learning: Hands-On Activities in Mechanics

Michele Korb and Julia Olkin, Cal State East Bay
Inquiry-Based Learning: Engaging STEM Faculty in the Teacher Preparation Pathway

Edward Price, CSU San Marcos
A Guided Inquiry, Physical Science Curriculum for Future Elementary Teachers

Examples of IBL in Math

Topaz Wiscons, Sacramento State
Stan Yoshinobu, Cal Poly, San Luis Obispo

Topaz Wiscons, Assistant Professor, Sacramento State, Department of Mathematics, topaz.wiscons@csus.edu

Stan Yoshinobu, Professor, Cal Poly SLO, Department of Mathematics, styoshin@calpoly.edu

The Four Pillars of IBL

Student Engagement in Meaningful Math	Student Collaboration for Sense Making	Instructor Inquiry into Student Thinking	Equitable Instructional Practice & Math Identity-Building

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Sense-Making “Continental Divide”

Non-IBL

Instructor does the bulk of the processing and primarily presents the material

IBL Zone

Students engaged in doing math. Students do much of the sense-making regularly.

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Groups at the Board – Seated Groups

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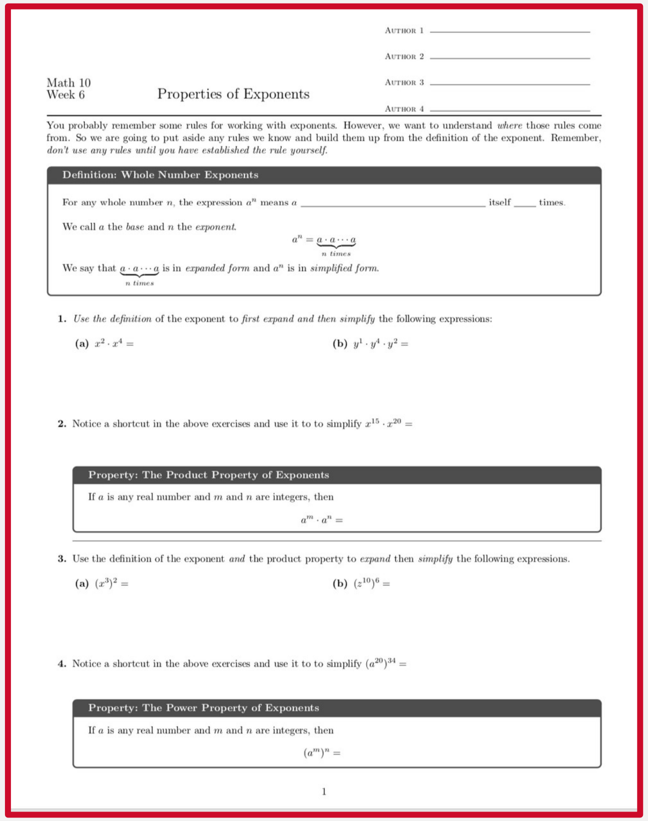
Examples of IBL in Math

Sample Handouts



Author 1 ____________

Author 2 ____________

Author 3 ____________

Author 4 ____________

Math 10
Week 6

Properties of Exponents

You probably remember some rules for working with exponents. However, we want to understand *where* those rules come from. So we are going to put aside any rules we know and build them up from the definition of the exponent. Remember, *don't use any rules until you have established the rule yourself.*

Definition: Whole Number Exponents

For any whole number n, the expression a^n means a ____________ itself ____ times.

We call a the *base* and n the *exponent.*

$$a^n = \underbrace{a \cdot a \cdots a}_{n\ times}$$

We say that $\underbrace{a \cdot a \cdots a}_{n\ times}$ is in *expanded form* and a^n is in *simplified form.*

1. *Use the definition* of the exponent to *first expand and then simplify* the following expressions:

(a) $x^2 \cdot x^4 =$ **(b)** $y^1 \cdot y^4 \cdot y^2 =$

2. Notice a shortcut in the above exercises and use it to to simplify $x^{15} \cdot x^{20} =$

Property: The Product Property of Exponents

If a is any real number and m and n are integers, then

$$a^m \cdot a^n =$$

3. Use the definition of the exponent *and* the product property to *expand* then *simplify* the following expressions.

(a) $(x^3)^2 =$ **(b)** $(z^{10})^6 =$

4. Notice a shortcut in the above exercises and use it to to simplify $(a^{20})^{34} =$

Property: The Power Property of Exponents

If a is any real number and m and n are integers, then

$$(a^m)^n =$$

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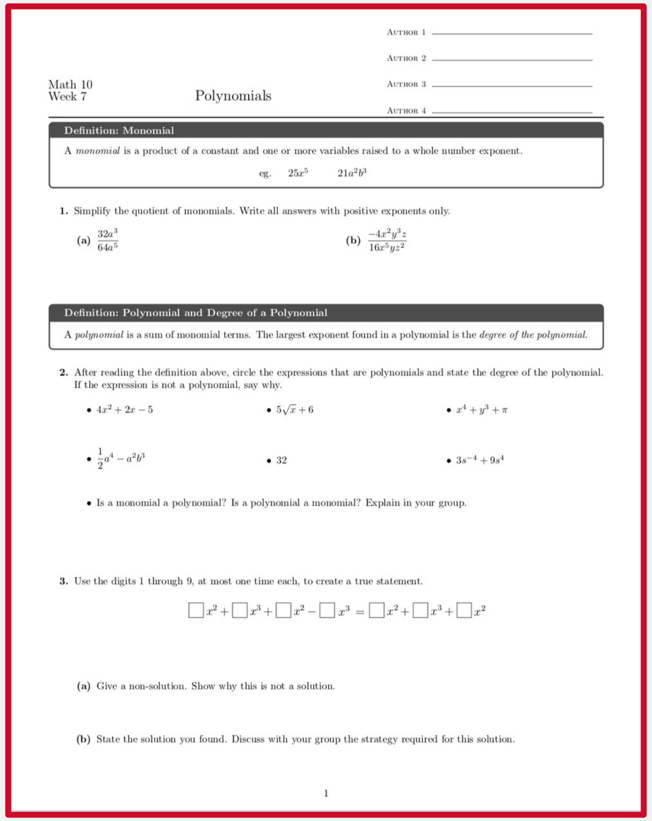

Author 1 ____________

Author 2 ____________

Author 3 ____________

Author 4 ____________

Math 10
Week 7

Polynomials

Definition: Monomial

A *monomial* is a product of a constant and one or more variables raised to a whole number exponent.

eg. $25x^5$ $21a^2b^3$

1. Simplify the quotient of monomials. Write all answers with positive exponents only.

(a) $\frac{32a^3}{64a^5}$ **(b)** $\frac{-4x^2y^3z}{16x^5yz^2}$

Definition: Polynomial and Degree of a Polynomial

A *polynomial* is a sum of monomial terms. The largest exponent found in a polynomial is the *degree of the polynomial.*

2. After reading the definition above, circle the expressions that are polynomials and state the degree of the polynomial. If the expression is not a polynomial, say why.

- $4x^2 + 2x - 5$
- $5\sqrt{x} + 6$
- $x^4 + y^3 + \pi$
- $\frac{1}{2}a^4 - a^2b^3$
- 32
- $3s^{-4} + 9s^4$
- Is a monomial a polynomial? Is a polynomial a monomial? Explain in your group.

3. Use the digits 1 through 9, at most one time each, to create a true statement.

$$\square x^2 + \square x^3 + \square x^2 - \square x^3 = \square x^2 + \square x^3 + \square x^2$$

(a) Give a non-solution. Show why this is not a solution.

(b) State the solution you found. Discuss with your group the strategy required for this solution.

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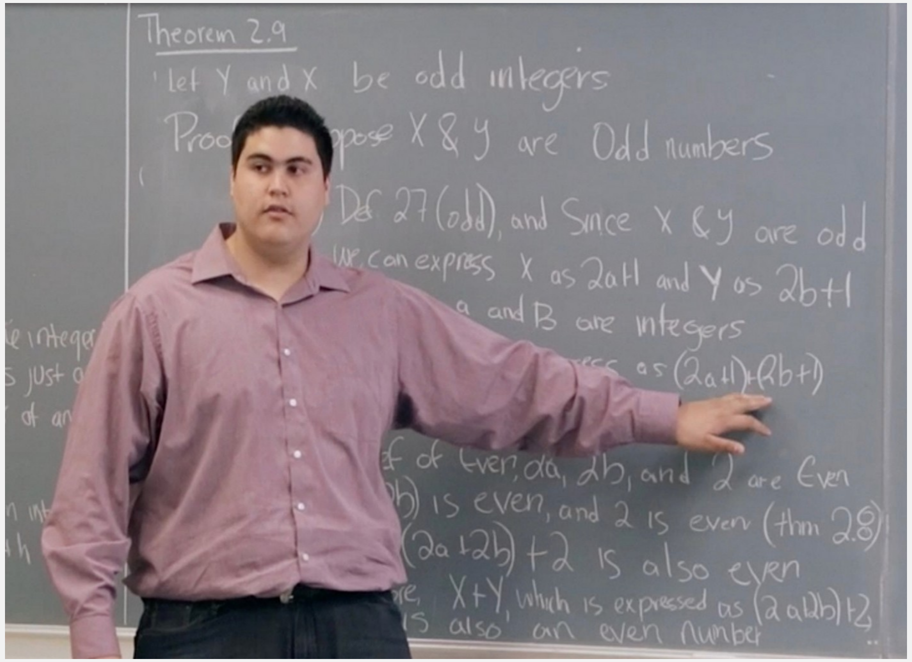
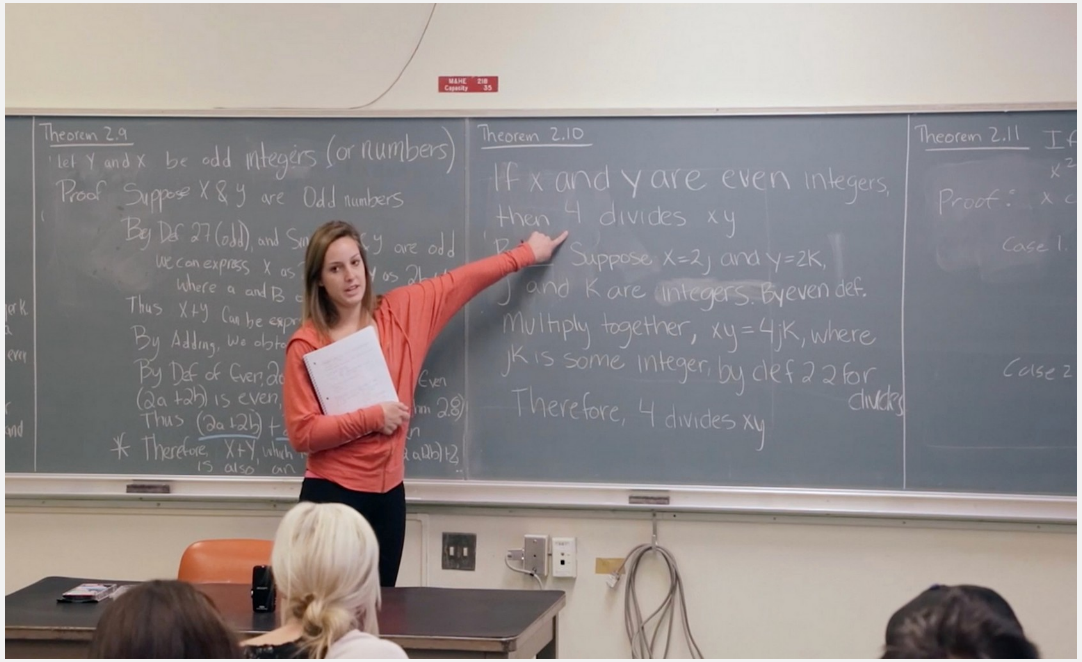
Students Presenting Solutions with Class Discussion





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Mentor in the Middle

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Collaboration During Office Hours

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IBL Key Features Type A

1. Students given carefully crafted problems to work for homework
2. Students present findings in class, by volunteering to present solutions.
3. Students in the audience discusses and review the presented solution, making amendments as needed.
4. Sometimes students work in groups or individually on the problems in
5. Mini-lectures/activities by instructor as need to launch a topic, check for understanding, move the class forward when student.

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IBL Key Features Type B

1. Class typically uses a standard textbook
2. Instructor starts with a short mini-lecture
3. Students work on specific tasks and ensures each group member understands
4. Instructor visits groups.
5. Class discussions used to make public main ideas and strategies
6. Think-pair-share (1-2-All) is used frequently

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Online Strategies

- TW:
  - Zoom + Chat Response Protocol + Breakout Rooms
  - Handouts
  - Short List of Prompts
  - Post ‘Lecture’ Screen Share from iPad.
- SY:
  - Carefully crafted handouts
  - Zoom + iPad + Apple pencil
  - Recording
  - SBG
- Easy start: Keynote and voiceover (for asynchronous)

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Solar Suitcase Course
Social Impact Solar Program

The Solar Suitcase Class – A Sustainability and Social Justice Motivated Inquiry Based Learning Class

Erik Helgren – Cal State East Bay

Collaborators:
Prof. Karina Garbesi – CSUEB Environmental Studies
Dr. Hal Aronson – Director of Tech and Education We Care Solar

Erik Helgren, Professor
CSUEB, Department of Physics
Erik.helgren@csueastbay.edu

Solar Suitcase Course
Social Impact Solar Program

Project Overview

- Origins: CSUEB HOST Labs, Hayward-Promise Neighborhood Program & re-design of Intro Phys. Labs to be inquiry based
- CSUEB cross-listed class ENVT/PHYS 307

"Social Impact Through Sustainable Solar Design"

- The class was designed to integrate sustainability, social justice and STEM learning with a Social Purpose
- Social Impact Solar (SIS) Program
  A Broad Collaboration: WeCare Solar

Erik Helgren *CSUEB/Physics* *erik.helgren@csueastbay.edu*

Solar Suitcase Course
Social Impact Solar Program

Activities

- Curriculum Centers on Building the Solar Suitcase - A small, rugged, off-grid solar electric system to power and light schools, orphanages, and refugee centers. Also ***Disaster Relief***
- Deep learning through: Doing, Teaching and Sharing = ***Head, Heart and Hands***
- Learn by Teaching Middle and High School Students
- Learning by Sharing Solar with the World's Neediest children
- Volunteer with local non-profits: **Grid Alternatives**

Solar Suitcase Course
Social Impact Solar Program

Results – at CSUEB

- We have developed a popular upper division B6 class that also satisfies the “sustainability” GE overlay graduation requirement.
- The class uses daily hands-on lab based activities interwoven with lessons about environmental and social justice issues related to Energy poverty.
- A higher number of students from traditionally underserved student populations are experiencing hands-on STEM/Physics learning.
- Students remain engaged beyond the classroom even after the course, e.g., Grid Alternatives

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Solar Suitcase Course
Social Impact Solar Program

Results – Broader Impact

- Social Impact Solar Program: we have partnered with 6 other CSU campuses and local community colleges to establish Solar Suitcase classes at
  - CSU Monterey Bay, Humboldt State, SF State, SLO, CSU Stanislaus and Sacramento State
  - Contra Costa Community College
- Summer 2018 workshop at Hoopa tribal center
- In conjunction with ***We Share Solar*** a total of over 14,500 students have received hands-on Solar Suitcase education during the six-year period 2013 – 2019.
  - 150+ (CSUEB), 400+ Hayward Unified School District
  - 550+ Solar Suitcases deployed to energy poor regions

we share solar®
Learn – Build – Share

Erik Helgren *CSUEB/Physics* *erik.helgren@csueastbay.edu*

Next Steps/Long-Term Plans

- Continue offering ENVT/PHYS 307 as a co-taught Inquiry-Based Learning course focused on Social Justice and STEM Learning.
- Work to Expand the Solar Suitcase curriculum model to more universities and school districts locally and nationally.
  - Fund raising – NSF ITEST, Foundations and Corporations
  - CSU STEM-NET
- Document/Share best-practices and lessons learned through journal articles; *"Head, Hands and Heart: An Integrated Solar Energy Education*," Gerbesi et al.

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Summary

- The Solar Suitcase class is an Inquiry-Based Learning curriculum using hands-on lab learning with the purpose of solar education and capacity building. Teaching Goals: Integrate Sustainability and Social Justice
- The Solar Suitcase (developed by WeShare Solar) and our curriculum
  - Middle or High School students as well as University-level students
  - Addresses both solar STEM concepts and energy poverty issues
- Expansion of the program through the Social Impact Solar Program to 6 other CSU campuses as local CC
- Addressing global energy poverty and opportunities for Emergency Preparedness

STEM with a Social Purpose

California Education Learning Lab (CELL) Project

California Challenges in STEM Energy Education

Marina Shapiro (PI) – CSUB
Danielle Solano (faculty co-PI)
Jesse Bergkamp (faculty co-PI)

Collaborators: Stephen Waller (Bakersfield College PI), Abbas Ghassemi (UC Merced PI), Chris Butler (UC Merced co-PI, Project Lead)

lifornia Education Learning Lab

Marina Shapiro, Lecturer of Chemistry and Biochemistry
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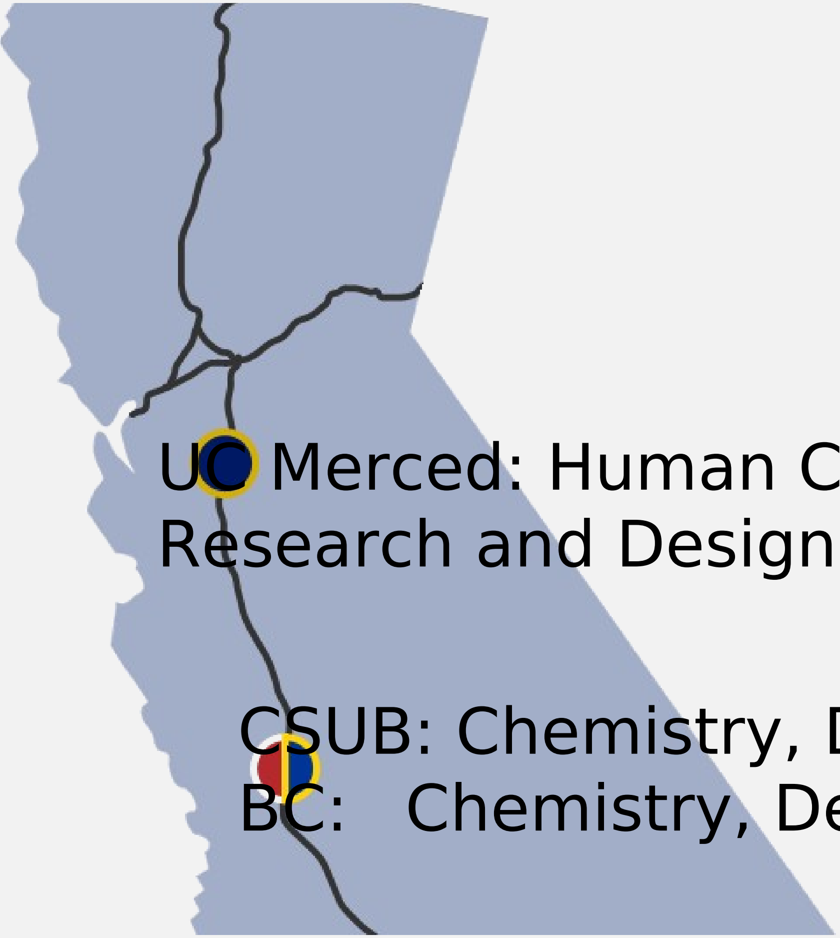
Project Overview

California Education Learning Lab (CELL) Project

- Three year grant funded by the Learning Lab (California Governors Office)

- Three Hispanic-Serving Institutions located in the Central Valley (San Joaquin Valley):
  - California State University, Bakersfield (CSUB)
  - University of California, Merced (UC Merced)
  - Bakersfield College

- Approximately 60% of the students are PELL grant eligible
- Approximately 70% are first-generation university students



From: https://www.visitcalifornia.com/region/discover-central-valley

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Project Goals

- Reduce large educational equity gaps in STEM fields that are experienced by Hispanic and other underrepresented minority (URM) students who live in California's Central Valley
  - Population in the San Joaquin Valley: slightly over 4 million and over 50% Hispanic
- Major factors for attrition:
- perceptions about careers in the STEM fields
- poor experiences with the academic culture and teaching pedagogy
- declining confidence due to demanding curriculum

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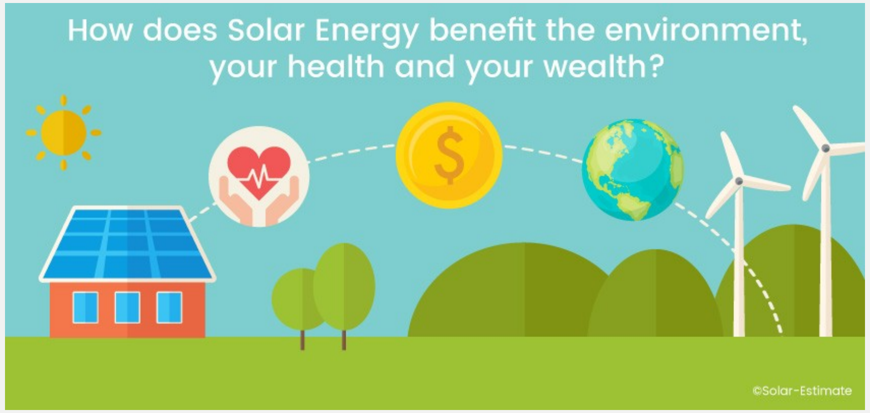
Project Goals

- Students do not have early exposure to real-world applications of their major to give positive insight into potential careers and do not always connect with upper-classmen to see successful peer role models, which research has shown to increase persistence (Zappe et al., 2012; Garcia-Otero & Sheybani, 2012)

Ultimate Project Goal is to impact:

1. student attitudes to learning STEM content
2. student success rates in specific lessons and final passing rates
3. equity gaps in student attitudes and success rates



From: https://www.solar-estimate.org/news/how-does-solar-energy-benefit-the-environment-your-health-and-your-wealth

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Activities

- Help URM students better see the connection between their studies and real-world problems

How?

- Will introduce concepts behind relevant technical problems applied to energy, water, and agriculture (problems relevant to the Central Valley) in General Chemistry (CSUB and BC) and Human Centered Research and Design (UC Merced) via novel approaches

and

- By increasing student engagement through:
    - active learning, applied learning through a career or workforce approach, and/or contextualized learning methodologies

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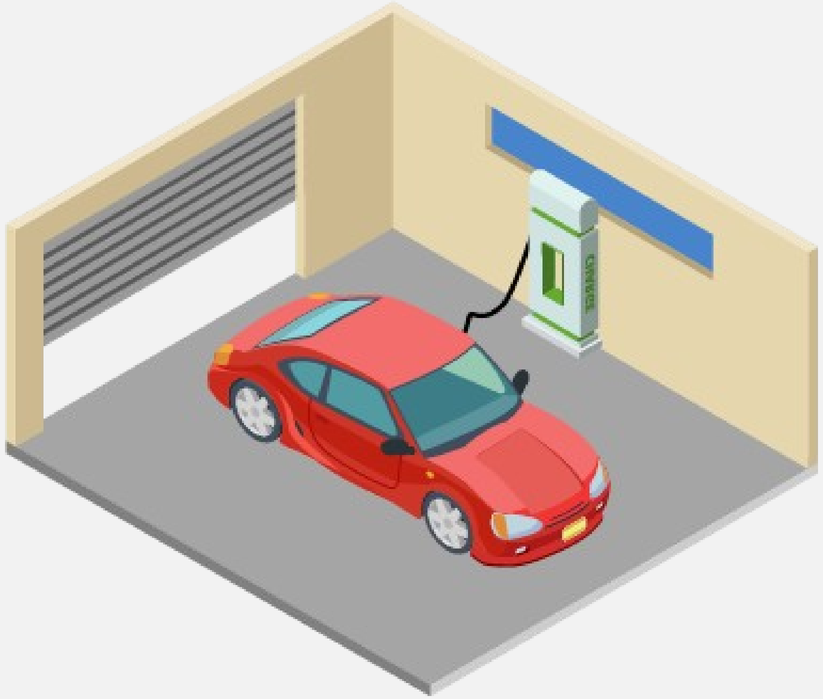
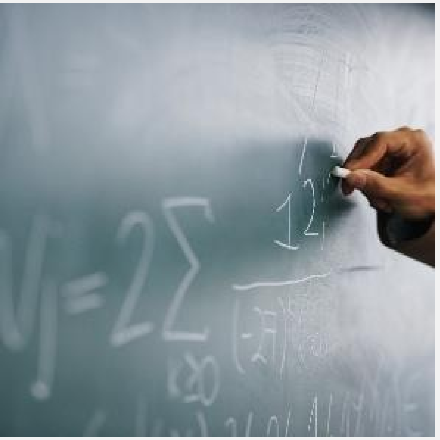
Activities





From: https://s3.amazonaws.com/solarassets/wp-content/uploads/2019/06/solar-panels-to-charge-electric-car.png

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Activities

CSUB and BC

Flipped Classroom-Enhanced-Process Oriented Guided Inquiry Learning (FC-E- POGIL)

- The CELL project will introduce Energy related concepts and applications to practical technical problems into gateway Chemistry courses via a novel combination of two pedagogies:
  - Flipped classroom
  - Process Oriented Guided Inquiry Learning (POGIL)

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Activities

POGIL

- a constructivist learning process where students work in-self-managed teams (Moog & Spencer, 2008)
  - Manager/facilitator
  - Speaker/presenter
  - Reflector/strategy anal
  - Recorder

From: https://pogil.org/about-pogil/what-is-pogil

- the process and the structure of the teams guarantees active learning and critical thinking from all team members
- As courses progress through POGIL, team members' roles rotate to allow all students an opportunity to lead, record, and report

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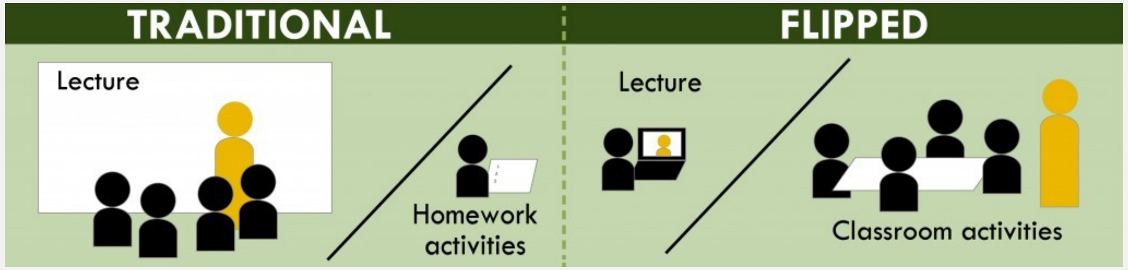
California Education Learning Lab (CELL) Project

Activities

Flipped Classroom

- The flipped classroom equalizes opportunity for students, especially students of lower socio-economic status and first generation students as research has shown that underserved student populations demonstrate greater outcomes from participation in HIP (Finley & McNair, 2013).
- Advantaged students have support systems in place to help complete homework and projects with paid tutors and advice from previous generations.
- With the relocation of the homework and projects to inside the classroom, disadvantaged students are brought even in benefit from the added interaction with the professor in class.



From: https://www.washington.edu/teaching/topics/engaging-students-in-learning/flipping-the-classroom/

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Activities

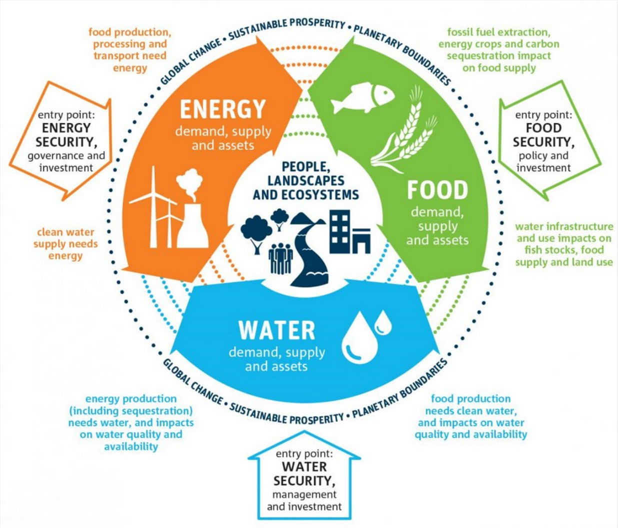
Challenge:
Trained STEM workforce from the Central Valley focused on energy

UC Merced

Human Centered Research and Design

- Design Focus
- Flipped Classroom
  - E-Learning Design Modules
    - Stakeholder Requirements
    - Evaluation Criteria
    - Specific Development

- Small Group Projects
  - Solar Energy
  - Self Selection
- Workshops
  - Solar Calculations
  - Customer Interactions



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Lessons Learned

- Early start with planning and budget (especially since working with three campuses)
- Allow extra time to develop novel inquiry methodologies, such as POGIL activities for Chemistry at the College level as current POGIL activities that currently exist may not align with course needs for this grant (college level Foundations of General Chemistry and Foundations of Organic Chemistry)
- This grant has a main focus that centers around technological innovation
  - Early start with planning with TLC (Faculty Teaching and Learning Center, Instructional Technologist), and software development company to develop Chemistry/Engineering Augmented Reality (AR) app

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Next Steps/Long-Term Plans

- Hire software development company to develop AR app that focuses on the real-world applications (as part of the inquiry learning hands-on activities in class)
- Augmented reality (AR) has gained attention in the educational field for its potential to enhance learning and teaching.
- Antonioli et al. (2014) found that AR can be useful in both bridging gaps and incorporating a more physical approach to learning.
- Bower et al. (2014) found that AR allows students to rescale virtual objects, such as molecules, to better understand the properties and relationships of objects that would either be too small or too large to examine without the use of AR. Furthermore, students are provided a clear representation of spatial concepts and have the opportunity to contextualize the connection between virtual objects and the real-world environment.

Next Steps/Long-Term Plans

- The AR app would allow students to experience a real life setting or go on a virtual field trip that they would be limited to having access to, such as navigating through the inside of a solar cell or internal combustion engine.
- After navigating through the AR app, students will work on their assigned critical thinking POGIL activities, which will align with the content presented during the assigned homework video (flipped classroom) from prior to coming to class, as well as the AR activity.
- The AR activity can continuously be used to help with inquiry while students work to answer the POGIL questions. In addition to the POGIL activities, online homework (Sapling) diagnostic “quizzes” will be used as assessment of students’ presented energy content knowledge, the AR Chemistry app will be able to collect data on the back end.
  - This will provide additional assessment data that the other presented methods are limited in terms of their capabilities of providing.

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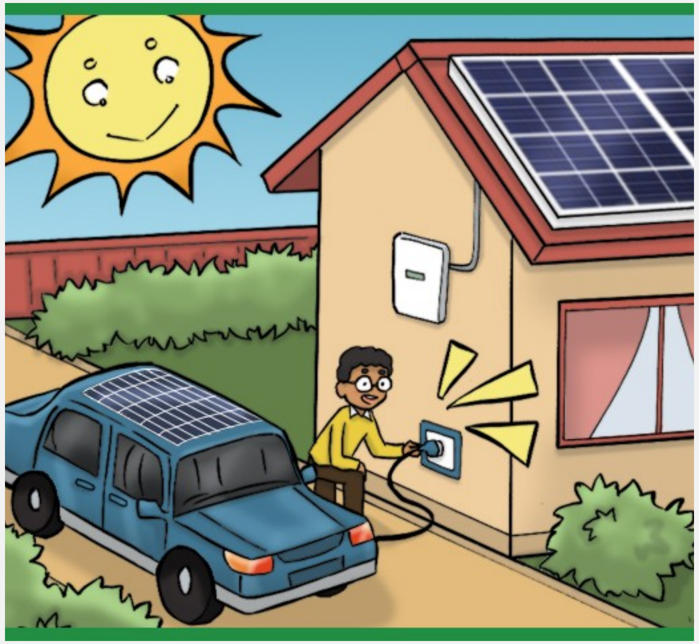
Summary

- CSUB and BC
  - Flipped Classroom enhanced POGIL
  - Focus on gateway Chemistry courses
- UC Merced
  - Develop Human Centered Research and Design course
  - Flipped Classroom
  - Focus on Engineering courses
- Develop Chemistry/Engineering AR app for all three campuses



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Inquiry-Based Learning: Hands-On Activities in Mechanics

Brian Self and Jim Widmann – Cal Poly, San Luis Obispo

Collaborators: Lots of students!

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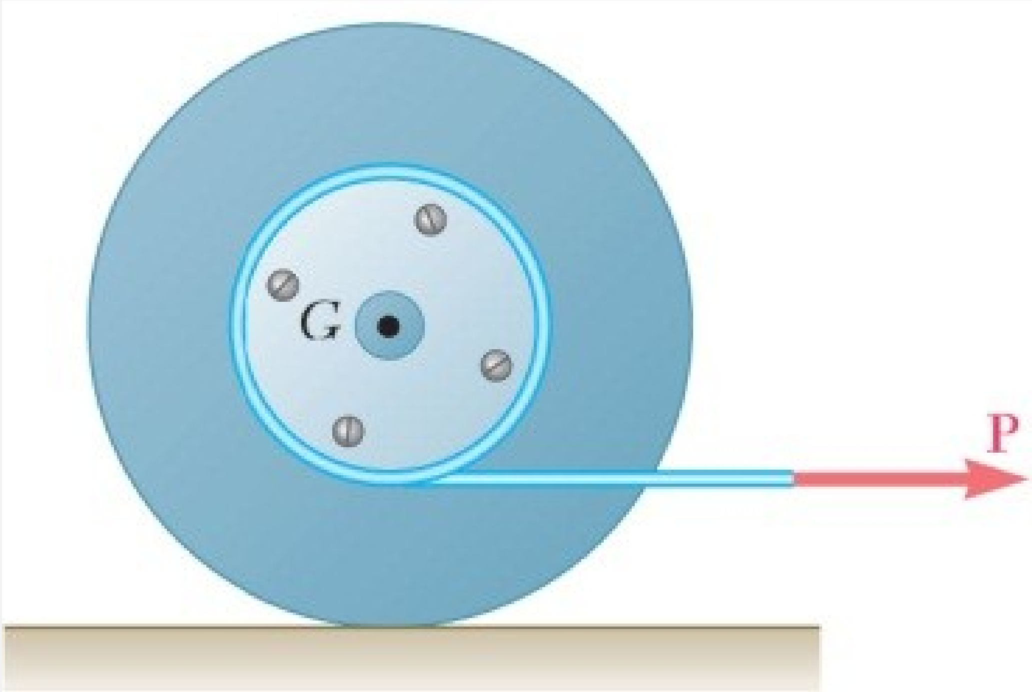

If you gently pull on the string..
(a) In which direction does the spool move?
(b) In which direction does the friction force act?

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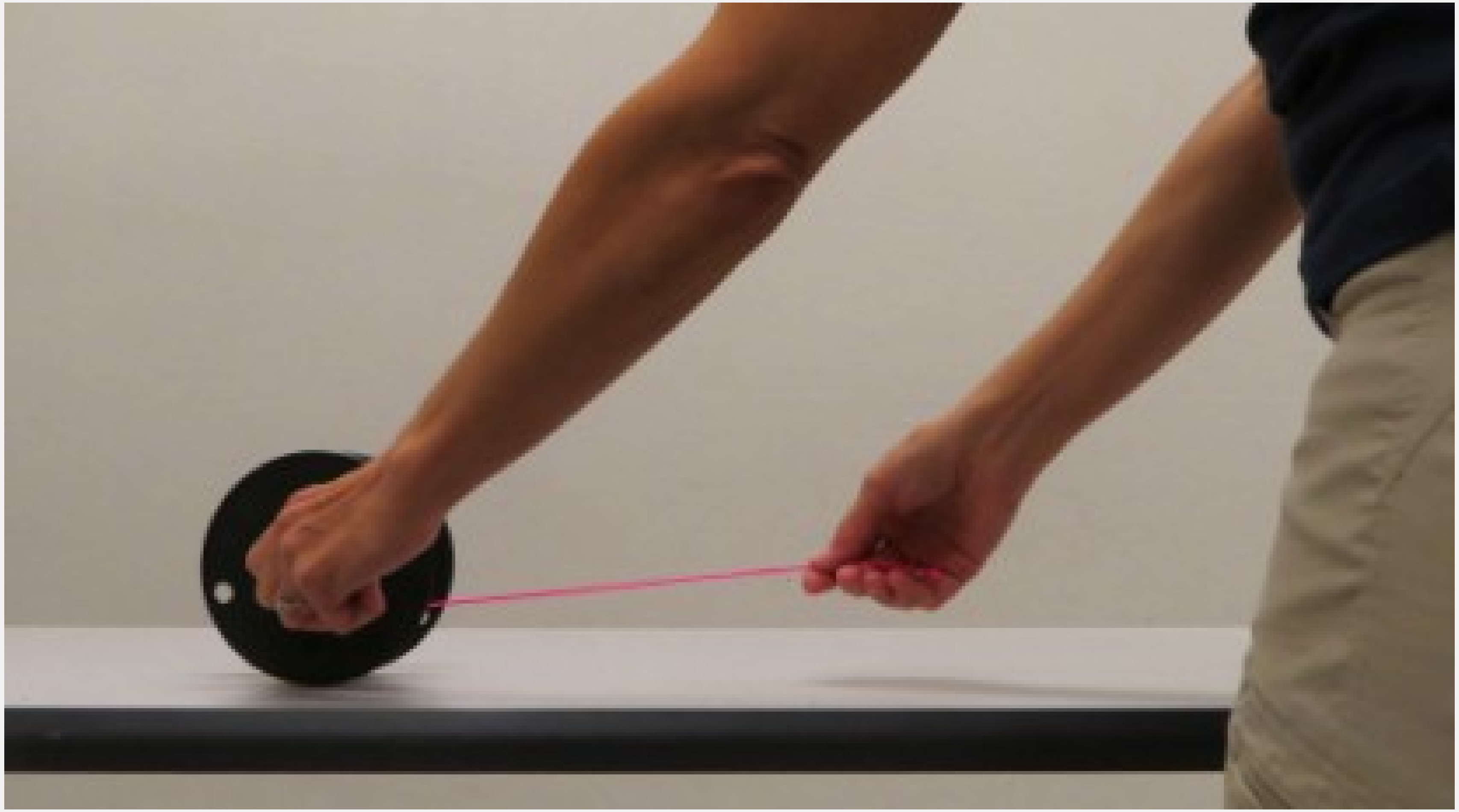
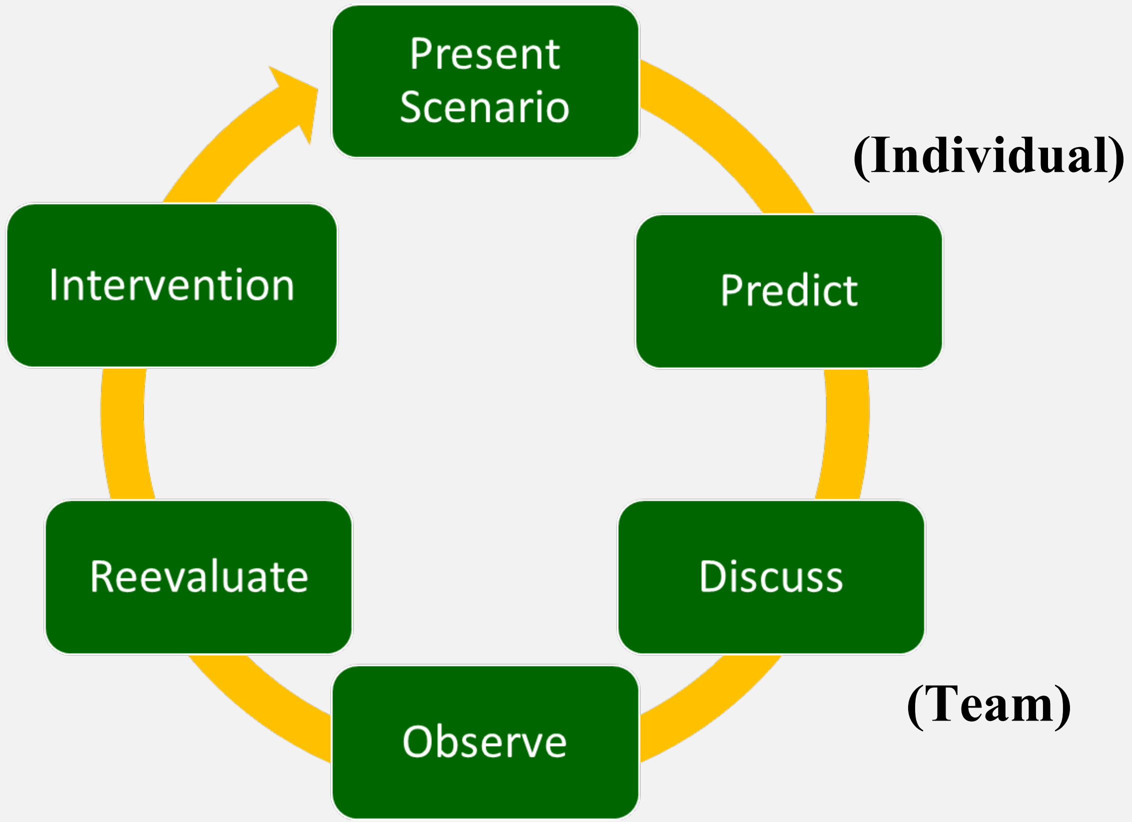


Project Overview

- Use a learning cycle: predict, observe, explain
- Emphasize conceptual understanding
- Use peer instruction and collaborative work
- Let the physical or digital world be the authority
- Evaluate student understanding
- Begin with the specific and move to the general



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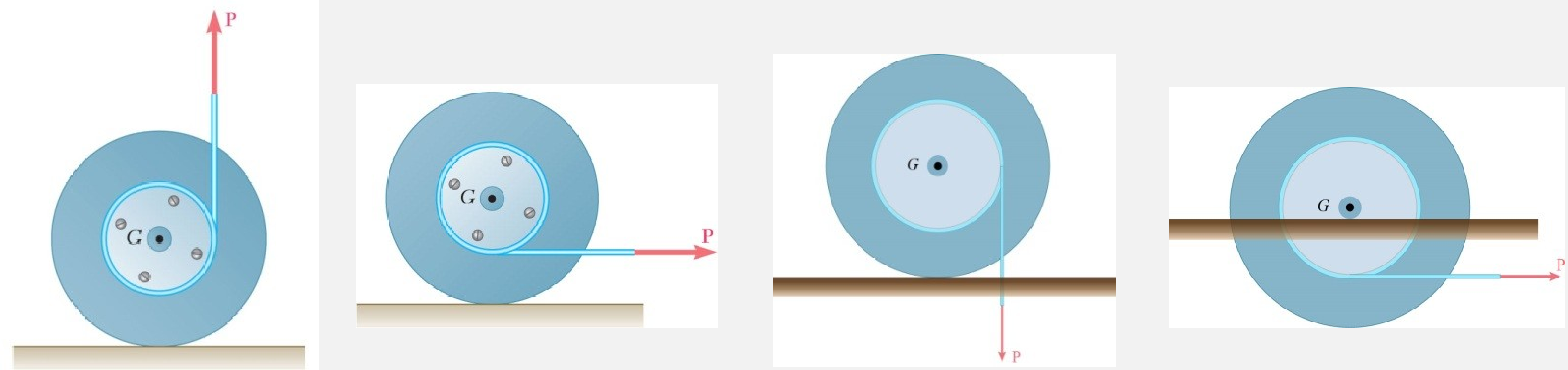
Activities

- Use “challenges” or physical scenarios to motivate students
- Provide worksheets to guide students along the correct path



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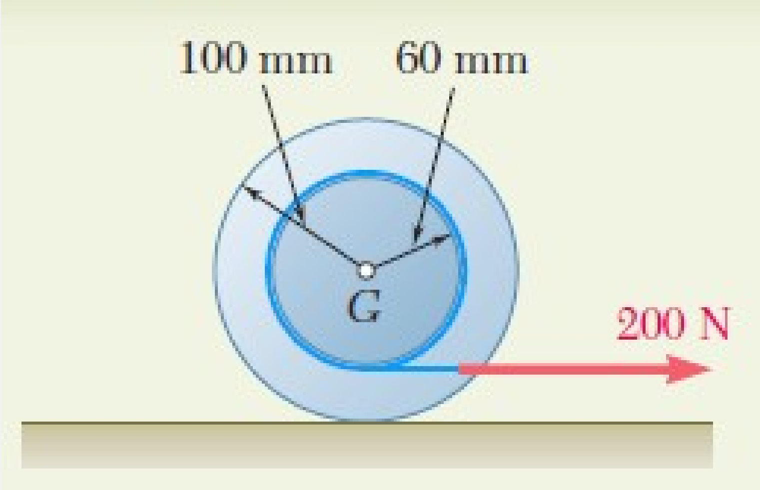
Activities

- **Still do calculations – and relate to “real world”**



A cord is wrapped around the inner drum of a wheel and pulled horizontally with a force of 200 N. The wheel has a mass of 50 kg and a radius of gyration of 70 mm. Knowing that $\mu_s = 0.20$ and $\mu_k = 0.15$, determine the acceleration of G and the angular acceleration of the wheel.

Discuss friction force on drive and non-drive wheels

Calculate the friction force on the drive wheel

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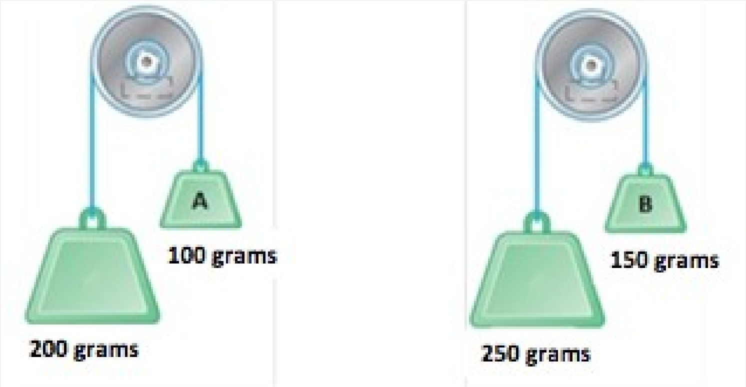
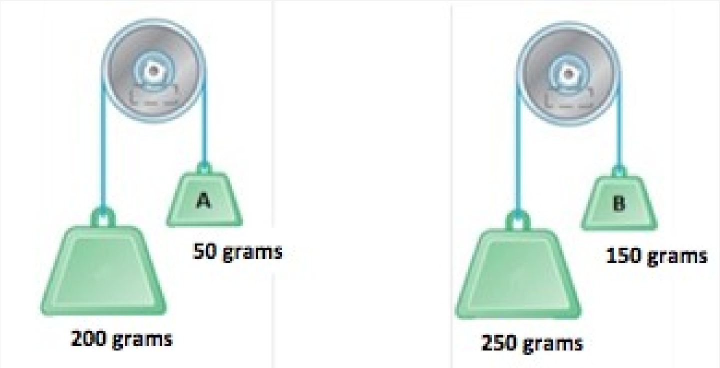
Activities

- **Mass, force, and acceleration**





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Activities

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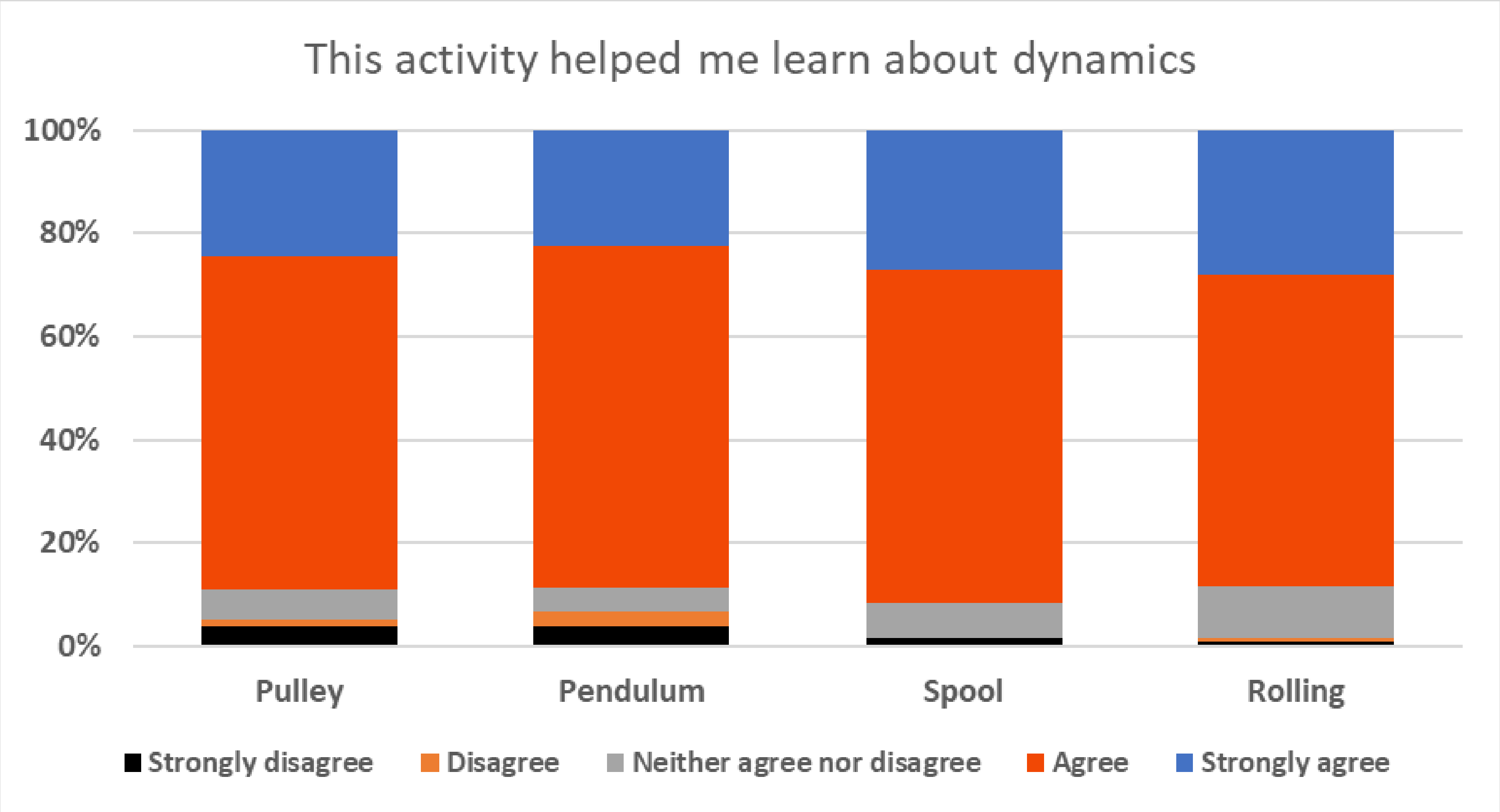
Results – Helped me learn



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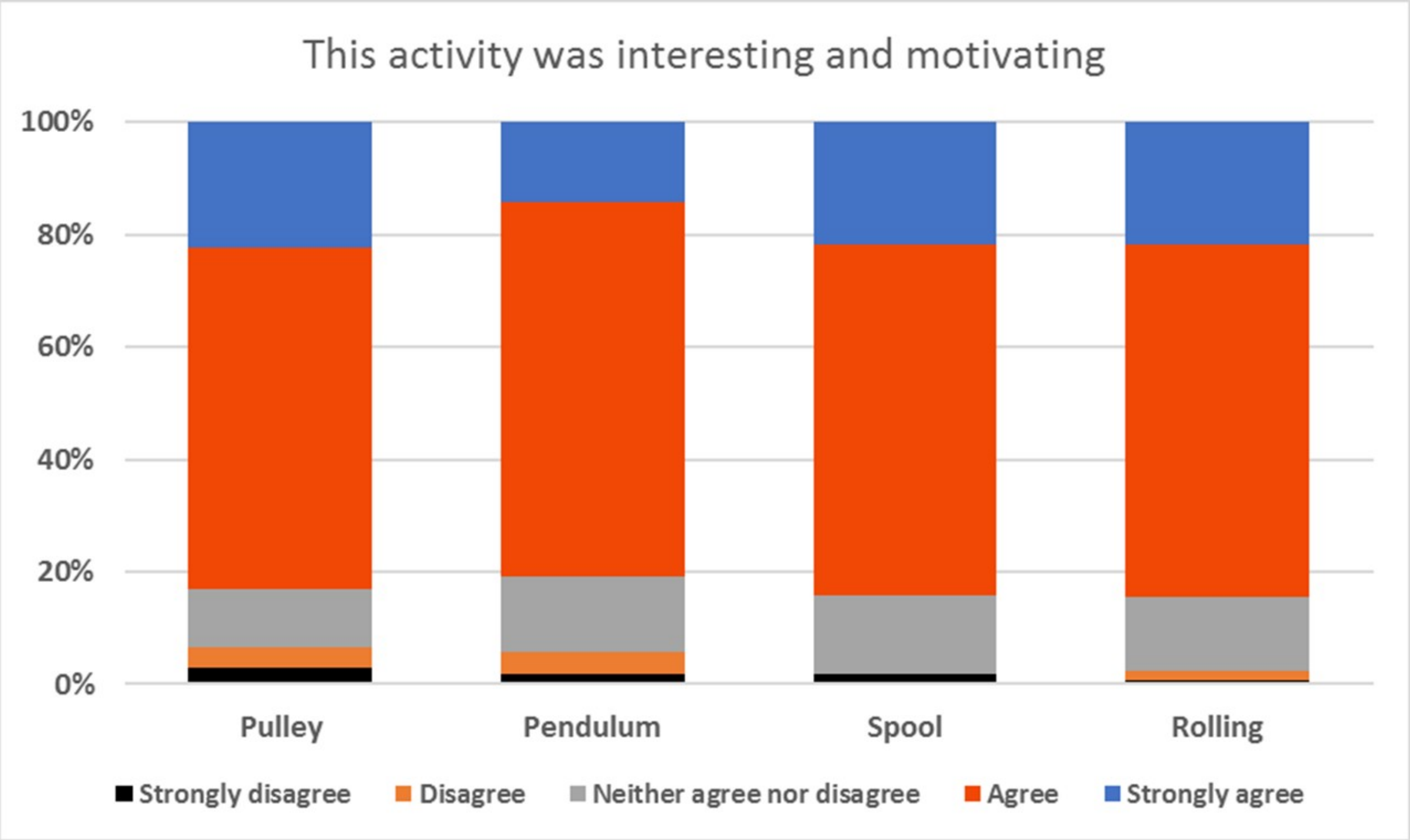
Results – Interesting and Motivating



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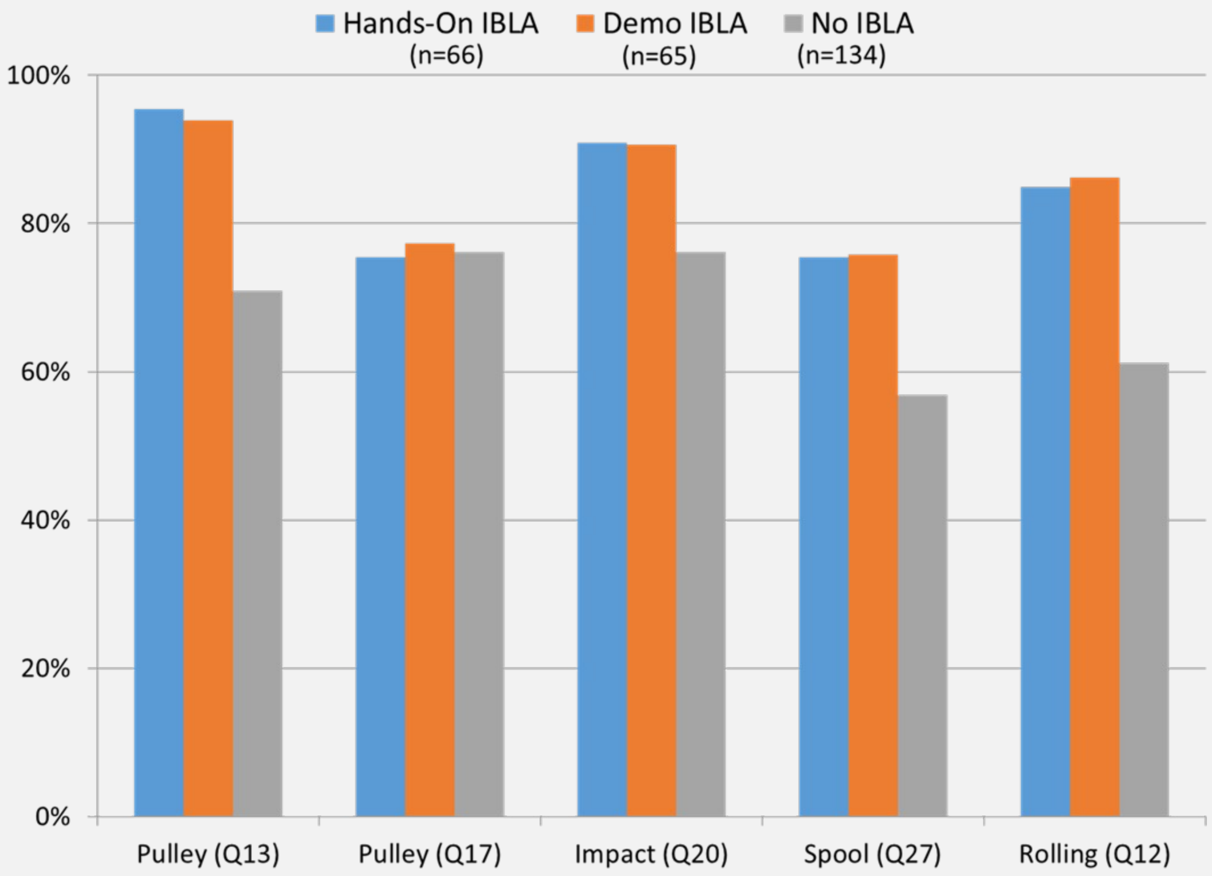
Results – Dynamics Concept Inventory



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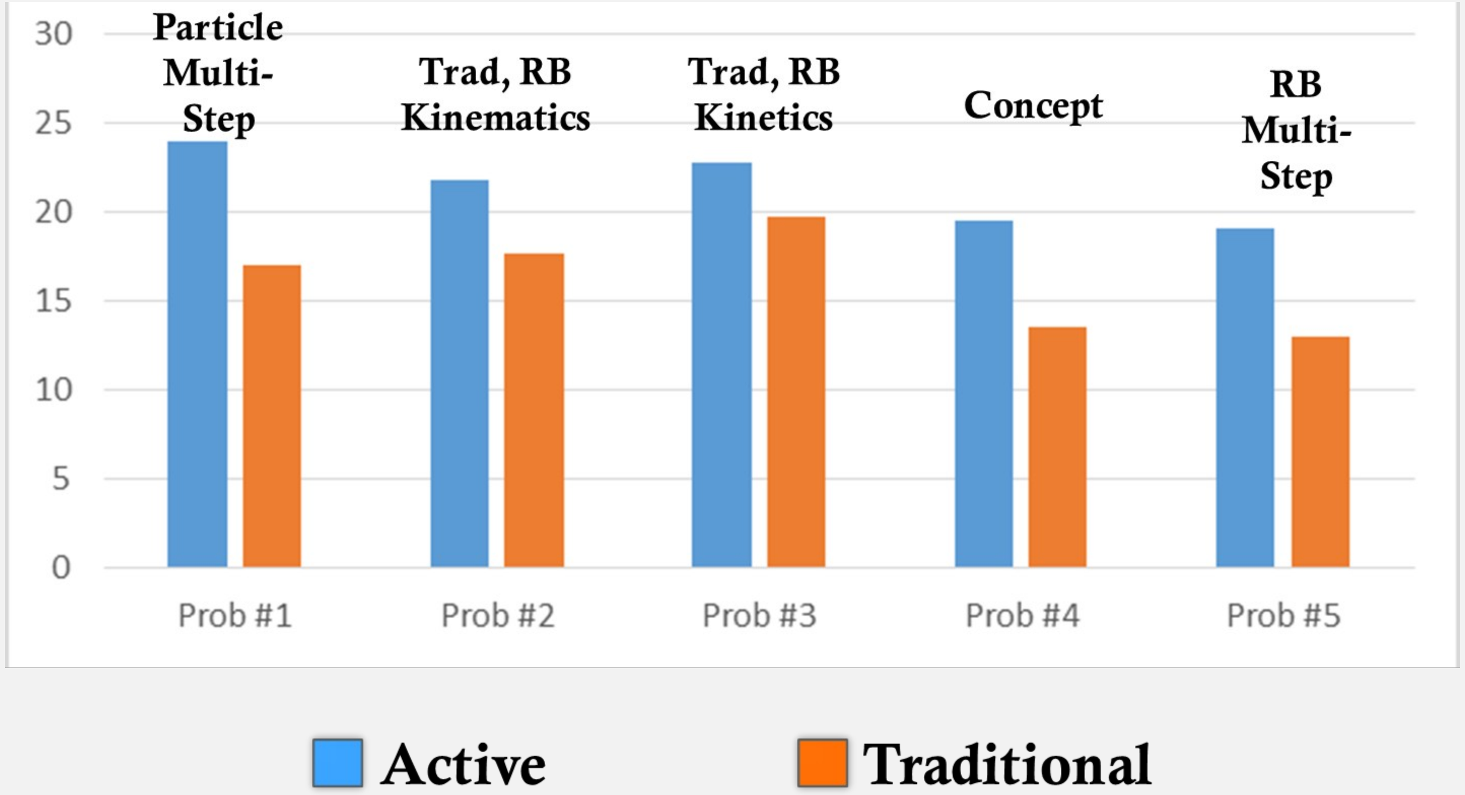
Results – Final Exam Scores



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Lessons Learned

- Pilot test everything
- Make it a welcoming environment where it is okay to predict incorrectly
- Need more than one scenario so can test new concepts and transfer
- Consider using variation theory when develop your predict-observe-explain cycles

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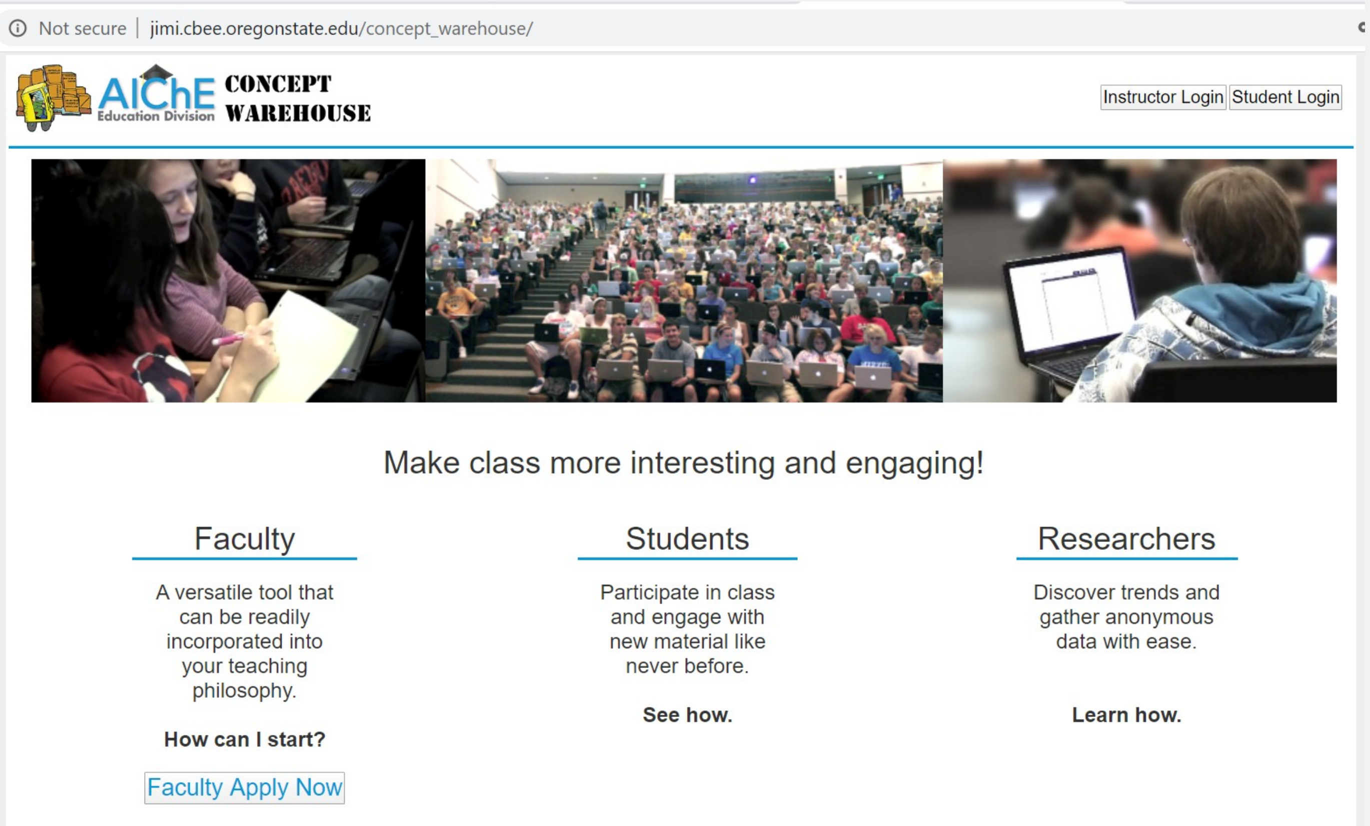
Next Steps/Long-Term Plans

- Develop 3D printed models for dissemination
- Create simulations and/or videos
- Concept Warehouse
  - Thousands of concept questions
  - Expanding into mechanics
- Active Learning Modules (Learning Lab Grant)



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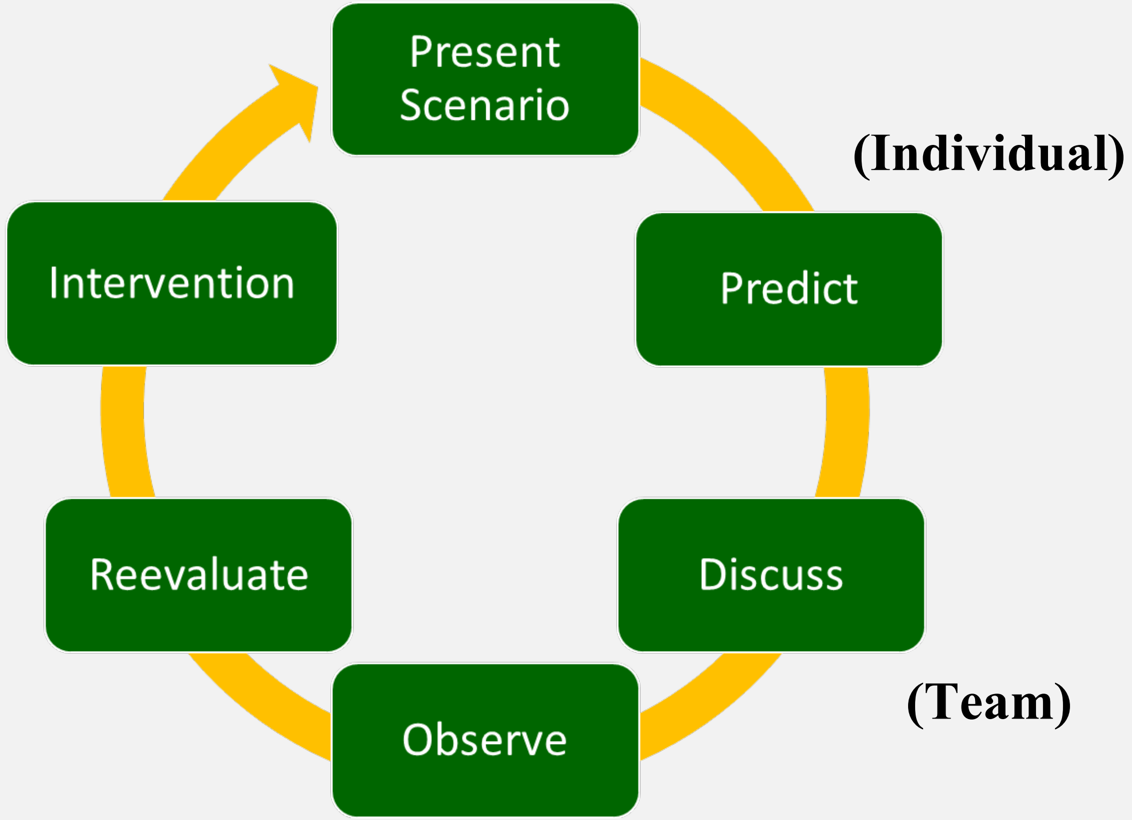
Summary

- Increase motivation by providing a physical scenario or challenge
- Focus on conceptual understanding
- Use multiple cycles:
  - Predict – observe – explain
- Let students know it is okay to be “wrong” during these activities



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CAL STATE EAST BAY

Engaging STEM Faculty in the Teaching Preparation Pathway

Inquiry-Based Learning: Engaging STEM Faculty in the Teacher Preparation Pathway

Michele Korb and Julia Olkin – CSU East Bay

Michele Korb, Associate Professor, Science Teacher Education, michele.korb@csueastbay.edu

Julia Olkin, Professor, Mathematics, julia.Olkin@csueastbay.edu

Background - NSF Grants

- **Faculty Learning Program (Julia)**
  - Program developed by UC Berkeley and Lawrence Hall of Science plus advisory panel
  - CSUEB now working with 4th cohort; every STEM discipline in College of Science involved
- **Aligning the Science Teacher Education Pathway (A-STEP)(Michele)**
  - Networked Improvement Community (NIC)- Science educators across CSU system
  - Goals include improving science teacher preparation at various levels and promote enactment of the NGSS

STEM Faculty Learning Program

- Year-long program. Brings together STEM faculty to learn, support each other in integrating active learning strategies in their courses.
- Build relationships and understanding of one another's teaching and learning contexts.
- Redesign STEM classes to apply what you learn and integrate new approaches to teaching.

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Engaging STEM Faculty in the Teaching Preparation Pathway

Activities

2-Day workshop to kick off year

Readings, trying out activities in class, working on activities in modules, learning about student conversations, motivations, learning styles, experts versus novices, stereotype threat, and more.

Seven Modules

Videotaping: protocol for watching each other.

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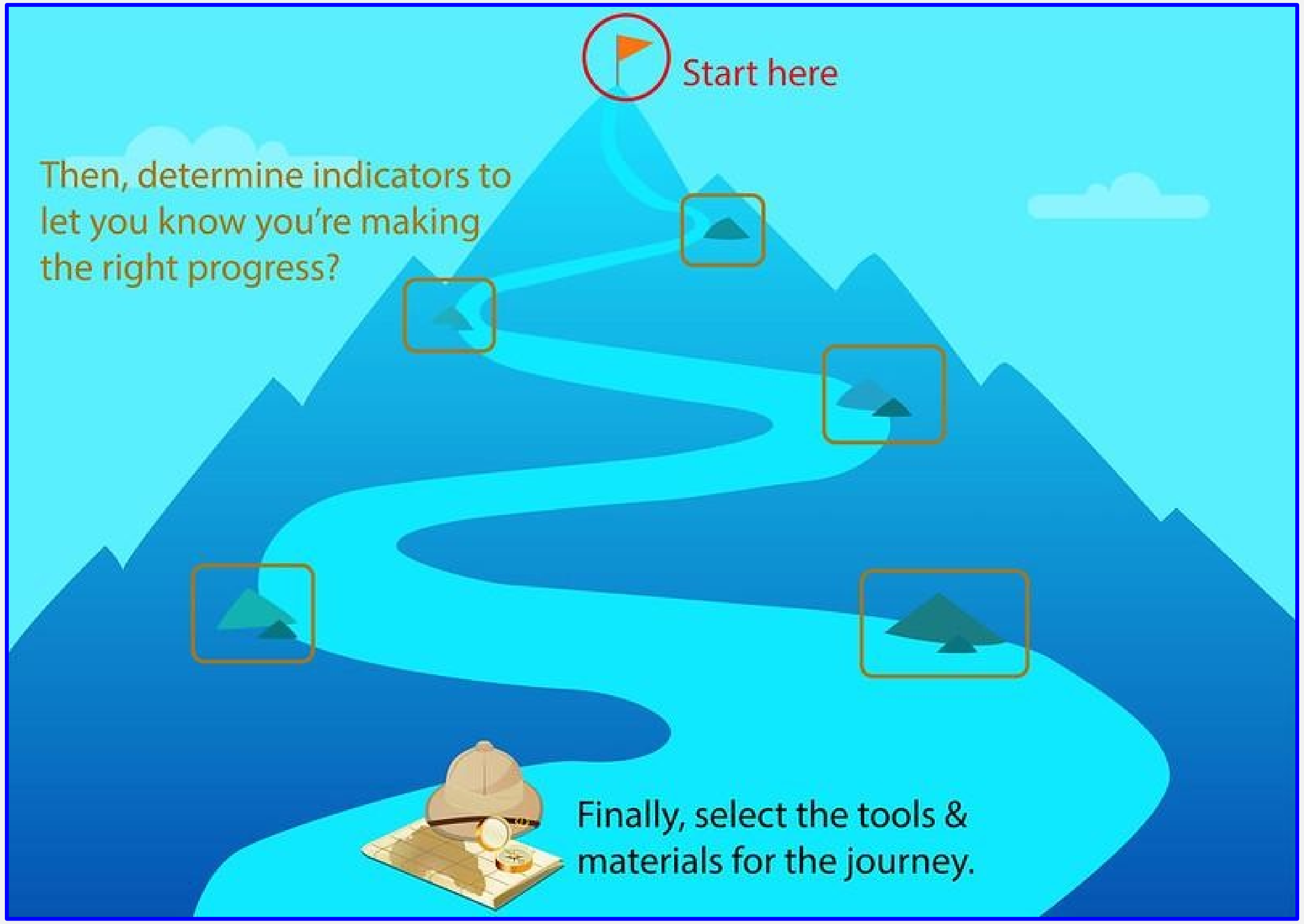
Engaging STEM Faculty in the Teaching Preparation Pathway

Instructor: Backwards Design



Faculty Learning Program: *Backwards Design Template*

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

Stage 1 – Identify Desired Results (Goals and Enduring Understandings)	
Goals What relevant goals will this design address (e.g., course objectives, learning outcomes)?	
Understandings: ▪ What are the big ideas students should understand? ▪ What are the enduring understandings that are based on the big ideas, and give content meaning & connect the facts & skills? ▪ What misunderstandings are predictable?	Students will understand …
Essential Questions: ▪ What provocative questions will foster inquiry to understand the big ideas and transfer learning?	Students construct meaning as they wrestle with the following questions…
Knowledge & Skills: ▪ What key knowledge and skills will students acquire as a result of this unit? ▪ What should students eventually be able to do as a result of such knowledge and skills?	Students will know … Students will be able to …
Stage 2 – Assessment Evidence	
Assessment Tasks: ▪ Through what tasks, which offer multiple opportunities to explain, interpret and apply their thinking, will students demonstrate their understandings? (e.g., quizzes, discussions, tests, observations, homework, journals)? ▪ By what criteria will understanding be judged? ▪ How will students reflect upon and self-assess their understanding?	Students demonstrate their understanding with the following tasks… Students self-assess their understanding through the following tasks…
Stage 3 – Learning Plan & Activities	
Learning Activities: What learning experiences and instruction will enable students to achieve the desired results?	
▪ How will students know where the unit is going and what is expected? ▪ How will instruction and tasks activate and connect students' prior knowledge? ▪ How will instruction and tasks engage students & sustain their interest? ▪ How will instruction and tasks encourage students to experience and explore the big ideas and enduring understandings? ▪ How will instruction and tasks offer students the opportunities to think about and discuss ideas with peers, and others more knowledgeable? ▪ How will instruction and tasks allow students to reflect on, evaluate, and revise their work? ▪ How will instruction and tasks be inclusive to the different needs, motivations/expectations, attitudes/beliefs, and abilities of learners?	

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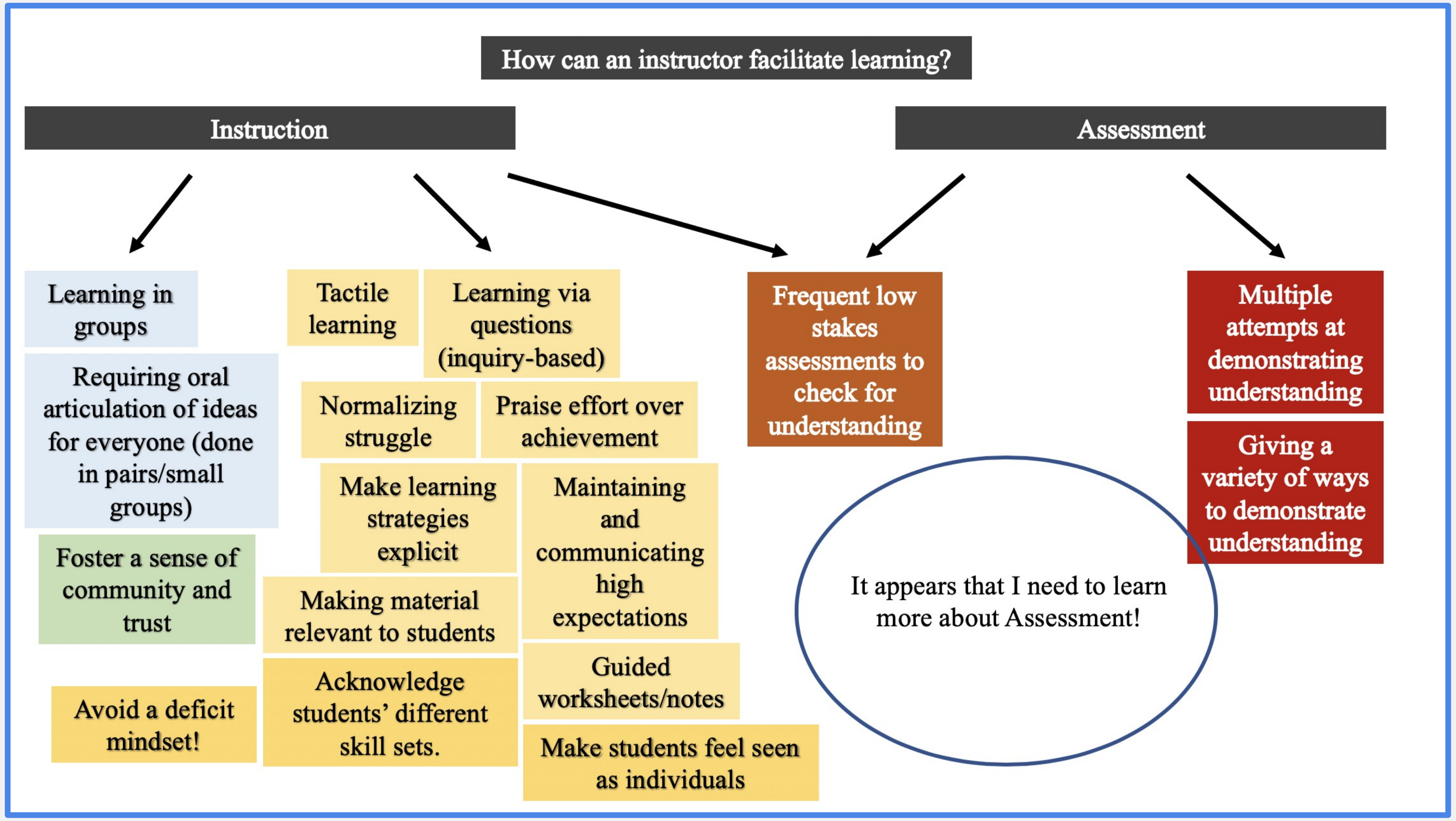
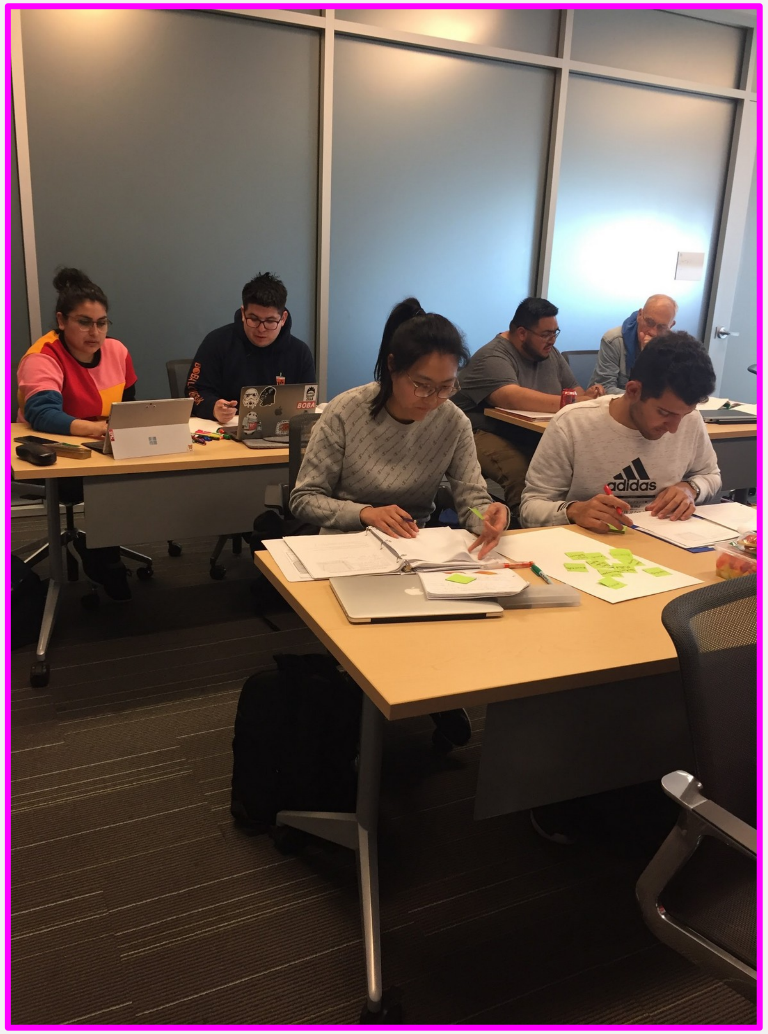
Engaging STEM Faculty in the Teaching Preparation Pathway

Student - Concept Maps





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Engaging STEM Faculty in the Teaching Preparation Pathway

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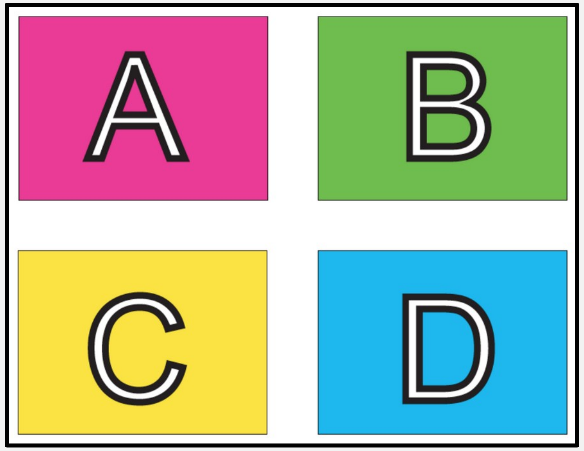
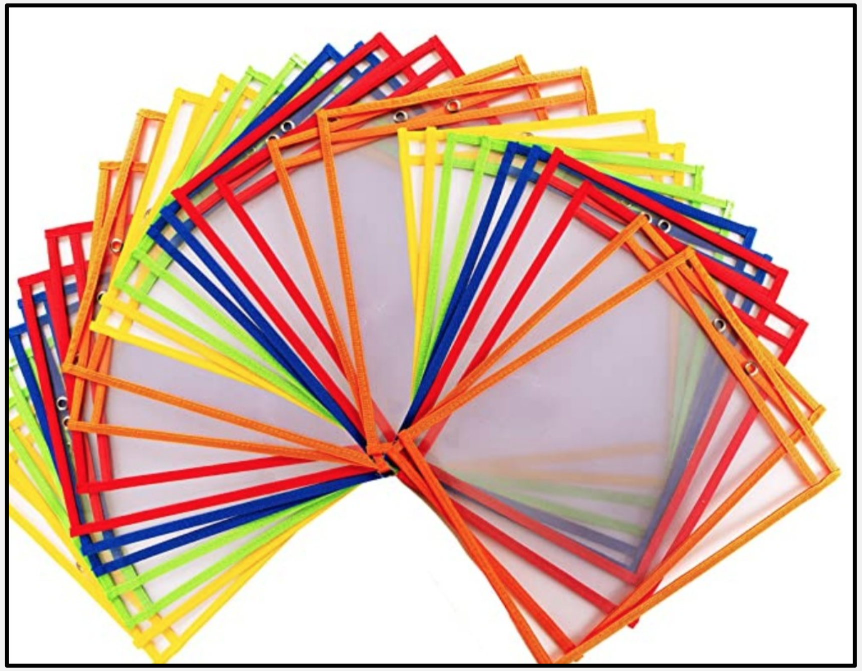
Student - More Examples

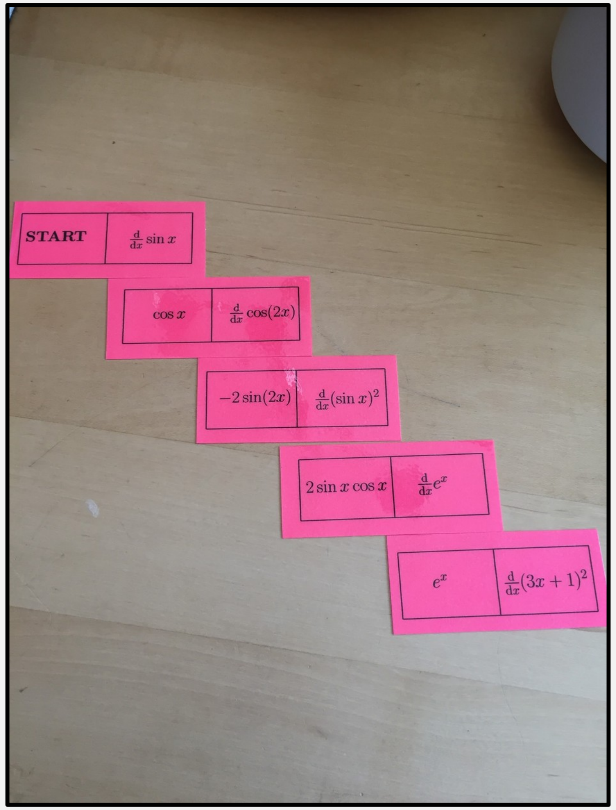


ABCD Cards for Concept Questions

Jigsaw & Think/Pair/Share



Individual or group whiteboard activities



Dominoes

Flipped Days

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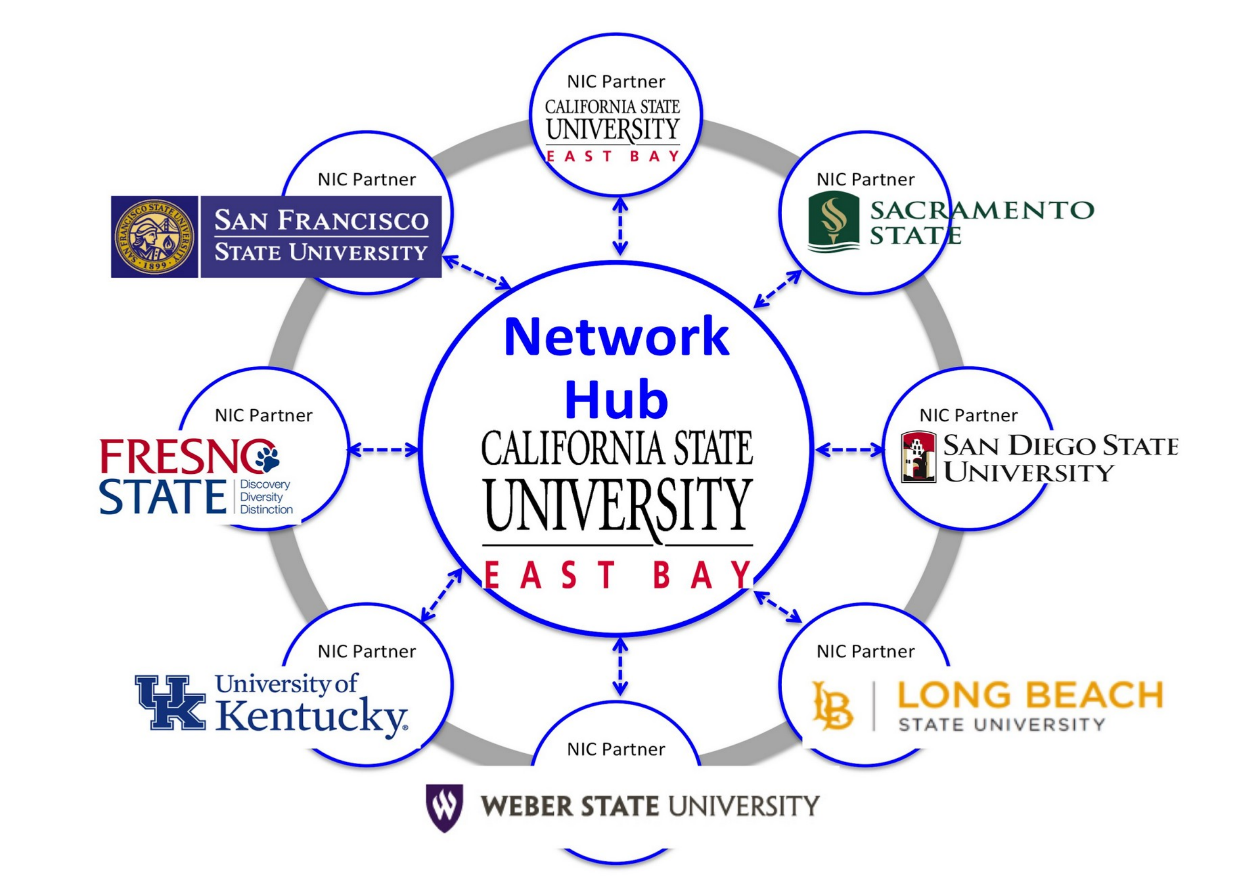
Engaging STEM Faculty in the Teaching Preparation Pathway

Alliance for Science Educators (ASE)
Networked Improvement Community (NIC)



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Next Steps/Long-Term Plans

- Continued discourse among communities of practice.
- Co-created grant opportunities across the campus and community.
- Continued outreach in school districts and among colleagues.

Networked Improvement Community

- Collaboration across the NIC promotes discourse related to how we prepare educators for enacting NGSS
- Co-created research questions and methods
- Co-creation of publications and presentations
- Involves communication of best practices (like FLP) and collaboration with science/ math faculty

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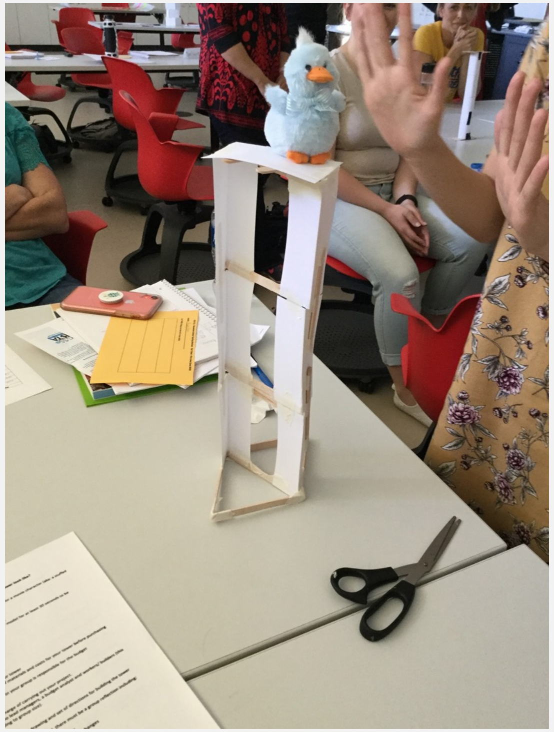
Engaging STEM Faculty in the Teaching Preparation Pathway

Results

As a result of our collaborations across colleges (Science and Education), we have fostered conversations regarding the importance of inquiry-based learning in classes for math and science majors as well as those for teacher preparation.

"The Institute for STEM Education a program of California State University East Bay serves as a hotbed of coordinated action."



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Lessons Learned

Faculty learning is essential for reshaping the landscape of math/ science learning.

Communication across disciplines and colleges provides for deeper understanding of shifts in teaching and learning paradigms that impact new generations of learners and teachers.

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A Guided Inquiry, Physical Science Curriculum for Future Elementary Teachers

Edward Price – CSU San Marcos

nextgenpet.activatelearning.com

Edward Price, Professor

CSU San Marcos, Department of Physics

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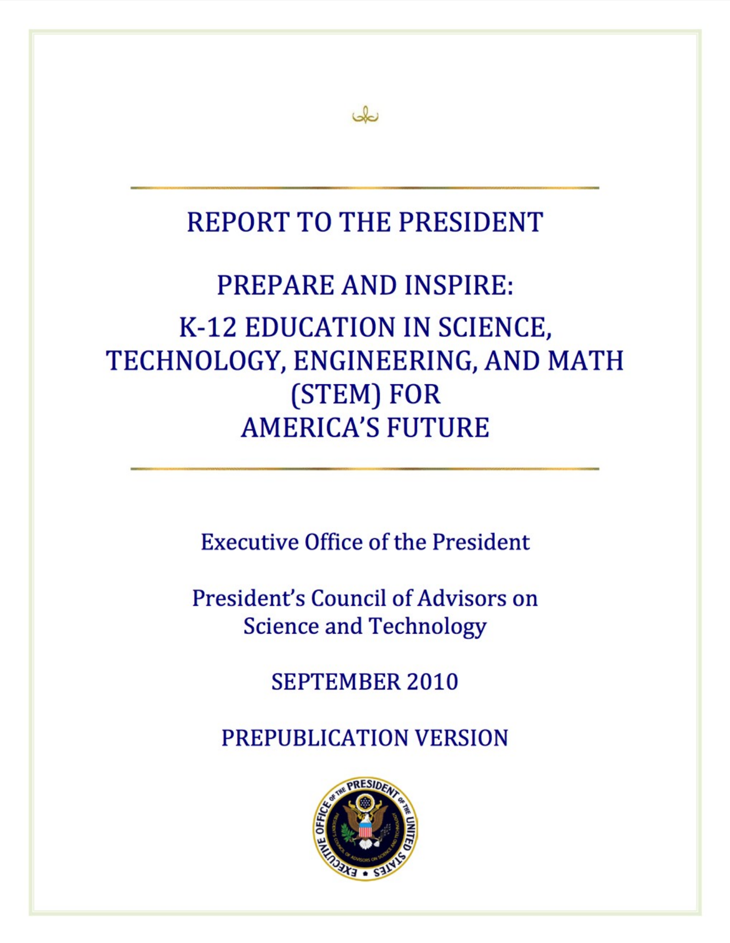
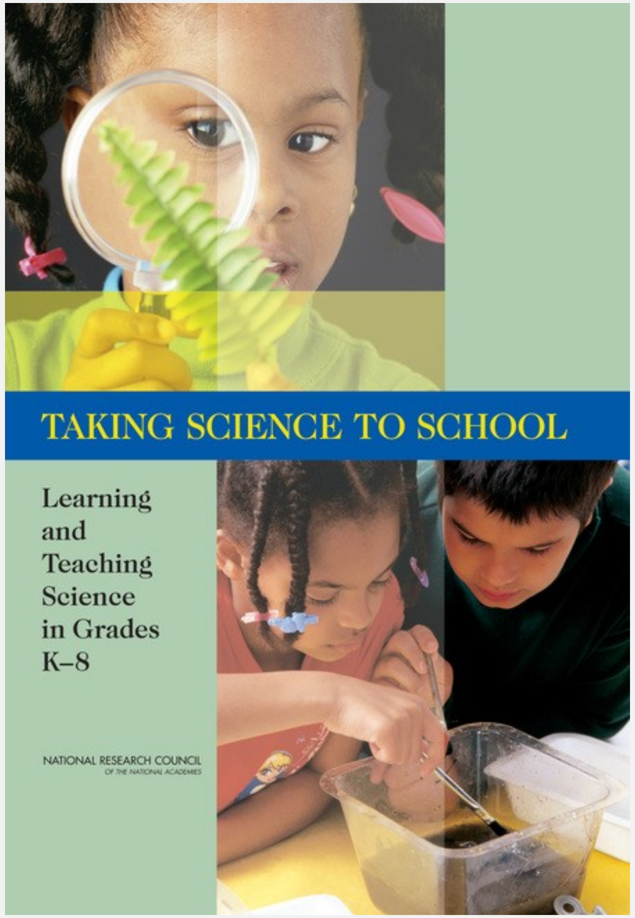
The Importance of Physical Science for Future Elementary Teachers





"Schools often lack teachers who know how to teach science and mathematics effectively, and who know and love their subject well enough to inspire their students."

- Prepare and Inspire

"science courses for teacher candidates… should mirror the opportunities they will need to provide for their students".

- Taking Science to School

California S
S

NEXT GENERATION SCIENCE STANDARDS
For States, By States

A Guided Inquiry, Physical Science Curriculum for Future Elementary Teachers

NGSS Physical Science Core Ideas

NGSS Science & Engineering Practices

NGSS Crosscutting Concepts

Ed Price *CSU San Marcos /Department of Physics* *eprice@csusm.edu*

Next Generation Physical Science & Everyday Thinking

The main learning goal of Next Gen PET is to engage students in the practices of science and engineering and use of crosscutting concepts so they will come to see that the *core disciplinary ideas* of science and engineering design *emerge* from *engagement* in those *practices*

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Next Gen

PET

Next Gen PET

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Next Gen PET Design Principles

A. Learning builds on **prior knowledge.**

B. Learning is a complex process requiring **scaffolding.**

C. Learning is facilitated through **interactions with tools.**

D. Learning is facilitated through **interactions with others**.

E. Learning is facilitated through the **establishment of certain specific behavioral practices and expectations**.

Goldberg, F., Otero, V. and Robinson, S. (2010). Design principles for effective physics instruction: A case study from Physics and Everyday Thinking. Am. J. Phys. **78** (12), 1265-1277.

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California State University
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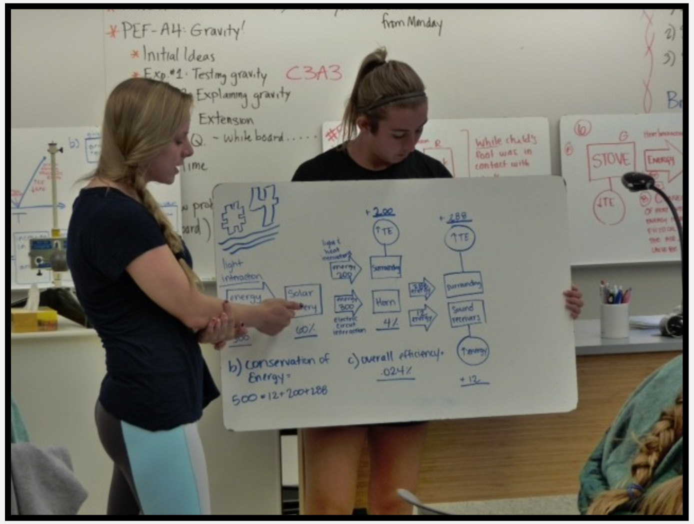
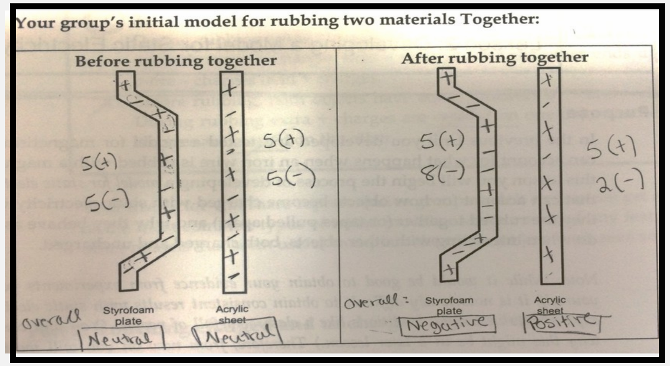
Next Gen
PET

Rich in student conversations, presentations, and artifacts of student learning





Instructors have many opportunities to listen to students' ideas and reflect on student learning

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California State University SAN MARCOS

Next Gen PET

The Next Gen PET Curricula

Modules	
• Developing Models of Magnetism and Static Electricity	
• Interactions and Energy	(PS3)
• Interactions and Forces	(PS2)
• Waves, Sound and Light	(PS4)
• Matter and Interactions	(PS1)
• Teaching and Learning Physical Science	

NGSS Practices

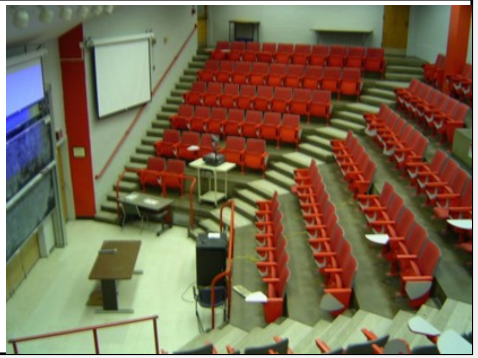
NGSS 4 Core Physical Science Ideas

Connections between learning, teaching and NGSS, embedded in content modules

Next Gen PET curricula

Instructor support

Studio & lecture versions,
plus lab activities



Engineering Practices are integrated throughout all modules

Optional Teaching and Learning activities support future teachers

Extensive online student & instructor resources

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Next Gen PET

Faculty Online Learning Community

- Meet every 2 weeks on zoom
- Share ideas, resources, learn, and grow professionally

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Faculty Online Learning Community

Significant increases (pre-post) in performance on multiple choice conceptual assessment

- In both lecture and studio formats
- Across all content modules

Significant increases (pre-post) in performance on constructed response content assessment (written explanations)

A Guided Inquiry, Physical Science Curriculum for Future Elementary Teachers

Next Gen PET developers

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Questions & Answers

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Next Steps/Closing Remarks

Dr. Frank A. Gomez
Executive Director, STEM-NET
Office of the Chancellor

https://www2.calstate.edu/impact-of-the-csu/research/stem-net