Improved Student Learning of Engineering Through Inquiry-Based Modeling Lessons Developed Using A System Thinking Perspective

Workshop Chairs

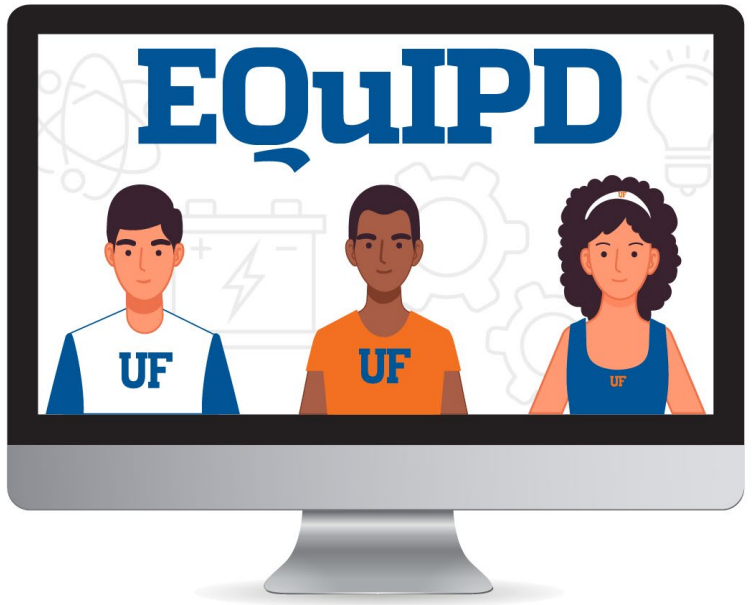
Dr. Nancy Jean Ruzycki

Dr. Krista Dulany

Dr. Lorelie Imperial

Florida Engineering Education Conference

February 25, 2022



Engaged Quality Instruction *through* **Professional Development**

UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Feel free to post your questions in the chat.
Or send an email to: *equipd@mse.ufl.edu*

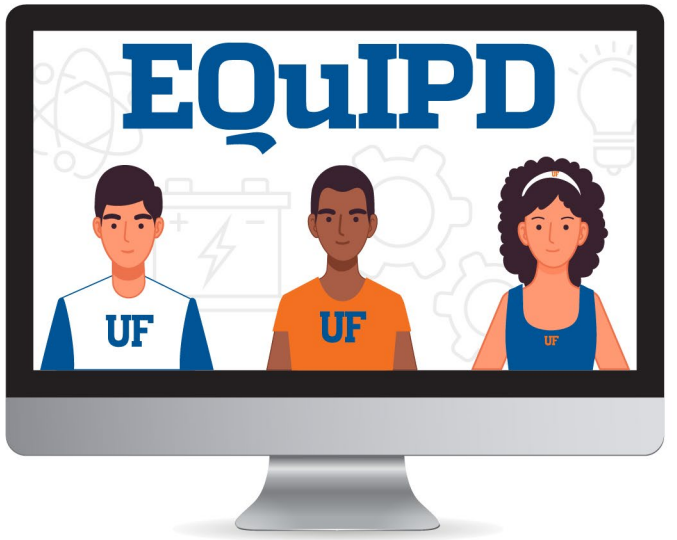
Additional EQuIPD Instructional Coaches:

Seleka Kerr	Jared Carter
Angel Danger	Leigh Arnold

EQuIPD

- Teacher professional development program.

- Funded by the US Department of Education through the Supporting Effective Educator Development (SEED)
  - 250 teachers
  - 10 districts of Florida (rural, urban, and suburban districts)



Engaged Quality Instruction *through* Professional Development

UF Herbert Wertheim College of Engineering
UNIVERSITY *of* FLORIDA

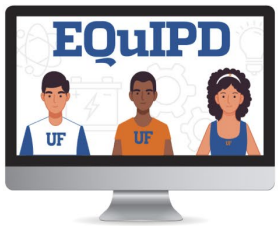
EQuIPD PD opportunities:

- Biweekly Teacher PD (on-going)
- Biweekly coaching
- Bootcamps
- Technology trainings
- Weekend PD

EQuIPD Professional Development Framework

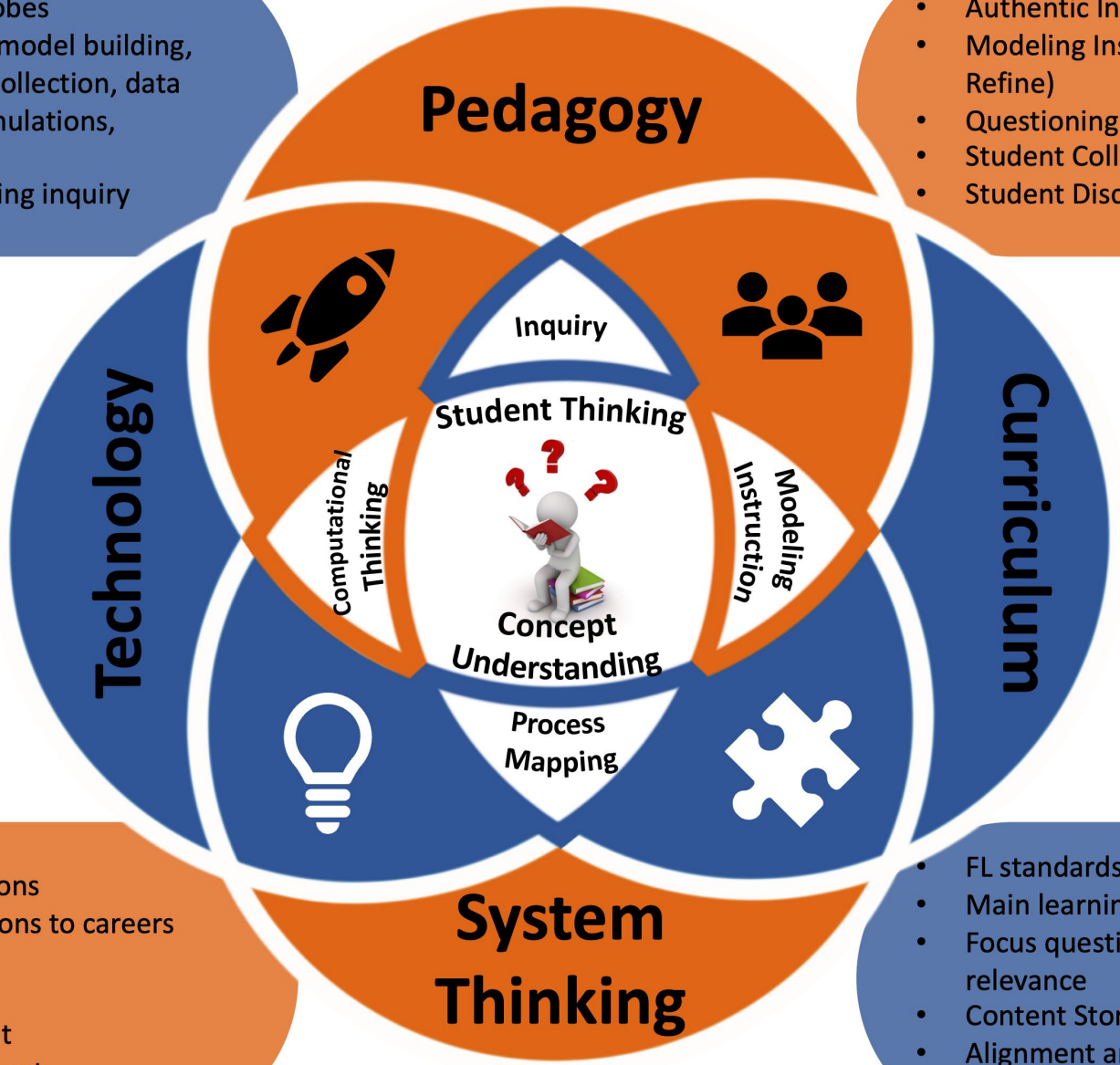
- Student use of sensors and probes
- Student use of technology for model building, computational thinking, data collection, data analysis, data visualization, simulations, programming
- Student use of technology during inquiry

- Authentic Inquiry
- Modeling Instruction (Elicit, Develop, Deploy, Refine)
- Questioning (Elicit, Probe, Challenge)
- Student Collaboration
- Student Discourse



Engaged Quality Instruction through Professional Development

UF Herbert Wertheim College of Engineering UNIVERSITY of FLORIDA



- Authentic Workforce Applications
- Real-world problems/connections to careers
- Engineering Design
- Process Mapping
- Ongoing Formative Assessment
- Authentic Summative Assessment

- FL standards linked to core conceptual models
- Main learning goal to align lesson to model
- Focus questions to provide engagement and relevance
- Content Storyline
- Alignment and sequencing of activities to support model development

Workshop Goals

- Understand how System Thinking, Concept Model Development and Inquiry Model Stages can be brought into core content classes.
- Deepen understanding of model development within an inquiry-based lesson in any subject area.
- Enhance understanding of the essential elements of an inquiry-based lessons.

Focus Question:

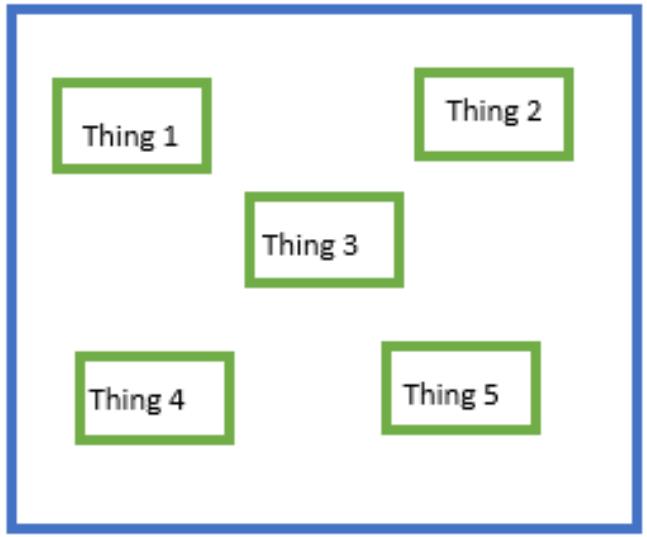
How can System Thinking, Concept Modeling, Design Thinking, and Inquiry Model Stages be utilized in the classroom to increase engagement and learning?

Workshop Outline

Approximate Time	Activity
5 Minutes	Workshop Introduction
10 Minutes	Conceptual Modeling, System Thinking, and Inquiry Model Stages
20 Minutes	Inquiry Experience: Part 1
5 Minutes	Break
10 minutes	Inquiry Model Stages Analysis

A concept model is a visual representation of a set of ideas or systems that clarifies the concept for both the thinker and the audience. It is a useful and powerful tool for anyone who needs to communicate complexity.

Model of Models



Storyline

The Storyline is the verbiage which explains the model. It will explain how the elements of the model connect to the larger model so that teachers and students understand what concepts build and compose the model.

What is System Thinking?

How we understand and process the world around us

Distinctions

Identifying…

- Boundaries between concepts, ideas, things
- What something is or is not
- Similarities & Differences

Relationships

Making connections between the elements (concepts, ideas, or things) in a system or conceptual model

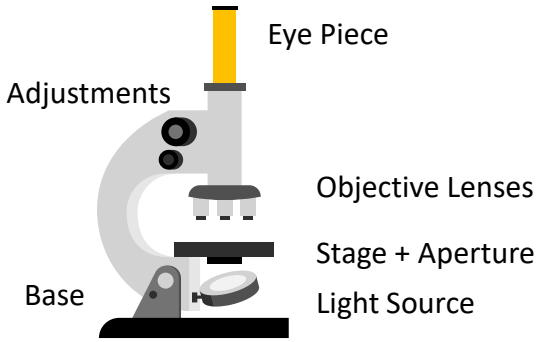
Parts to Whole

Creating a system or conceptual understanding from…

- The individual "distinct" concepts, ideas, things, parts
- The relationships between them

Perspectives

Use different perspectives to construct and test the systems and conceptual understanding of ideas

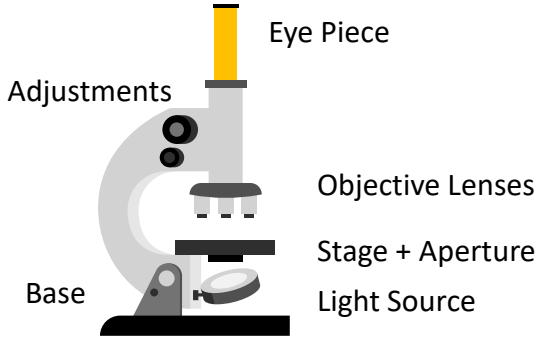


Eye Piece + Adjustments + Stage = Focus

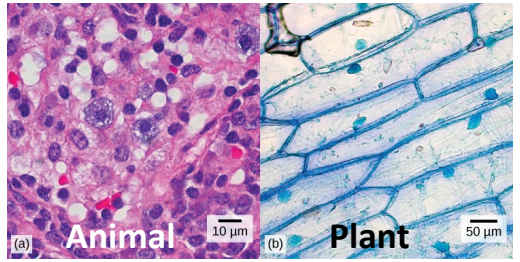
Eye Piece + Objective Lenses = Magnification

Light Source + Aperture = Brightness

LIGHT MICROSCOPE



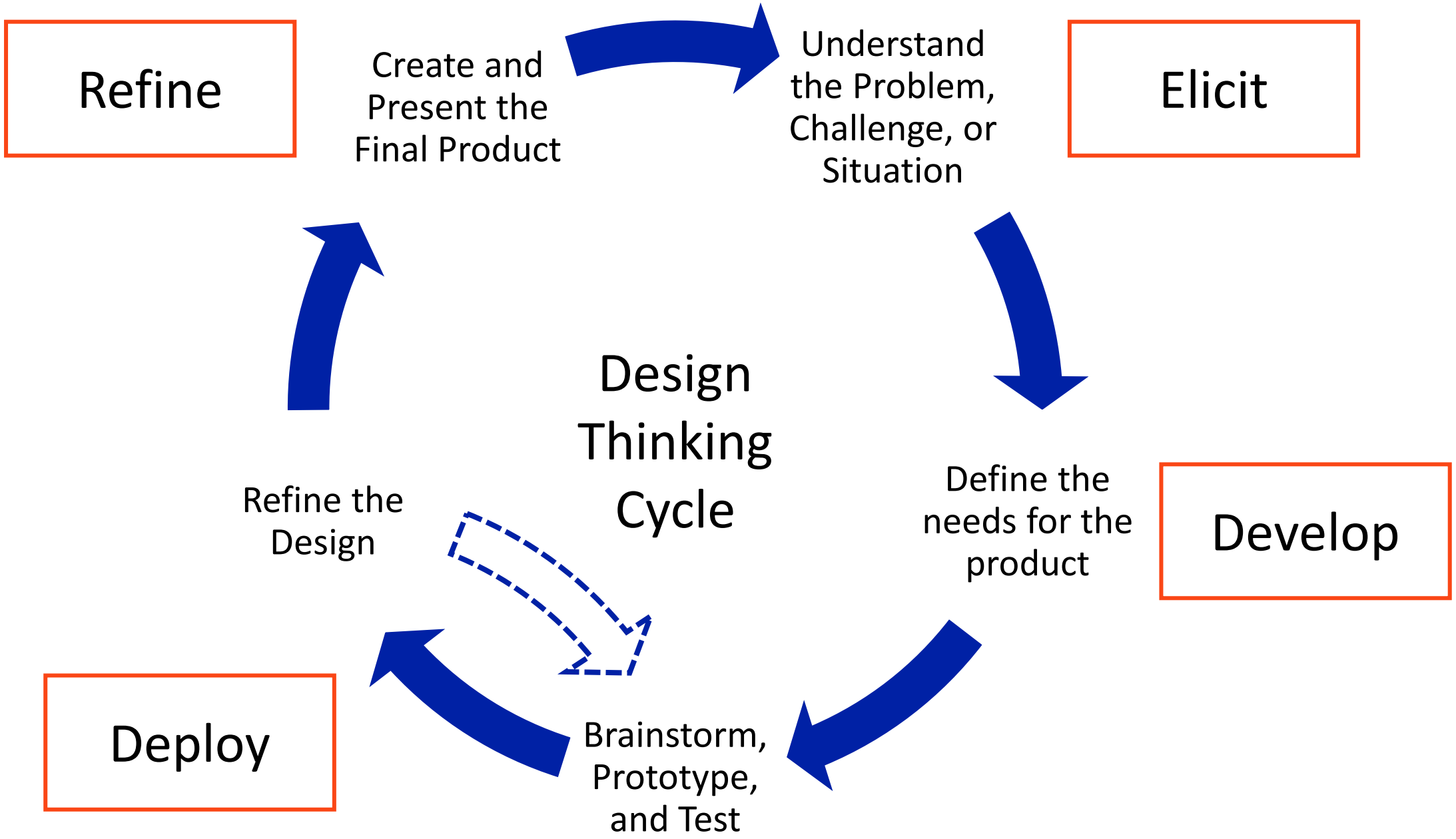
Purpose: different subject areas
User versus Manufacturer
K-12 versus Higher Ed



https://cnx.org/contents/GFy_h8cu@9.85:6Yva7EBg@2/Introduction

Inquiry Model Development Stages

	Elicit	Development	Deployment	Refine
Purpose	**Engage prior knowledge** related to the learning goal/model.	**Experience** with the elements of the **model**.	**Use the model** and apply it to a new application.	Provide learners with **opportunities to reflect** on what they have learned.
Teacher Lens	Creates **interest** and generates **curiosity**.	**Creates a structured set of activities** based on model elements .	Creates activities to allow students to **use the model in a real-world situation**.	Creates activities that **allow students to share the refined model** in multiple ways of communication.
Student Lens	**Identify information they know and do not know** about the phenomena or model.	**Collect, record observations and ideas**, and use information to develop a model.	**Tests the model** out in a **new application** or situation.	Students look at **how well the model performs in a real-world situation.**


Refine
Create and Present the Final Product
Understand the Problem, Challenge, or Situation
Elicit
Design Thinking Cycle
Refine the Design
Define the needs for the product
Develop
Deploy
Brainstorm, Prototype, and Test

Learner Experience

Inquiry Model Development
and Engineering Design Stages
in an Activity

Elicit/Understand

- Respond to the following questions in the handouts provided.

- **What defines a footprint?**
- **What does a footprint measure?**

Elicit/Understand

Pandemic Field Hospital Set Up

Focus Question

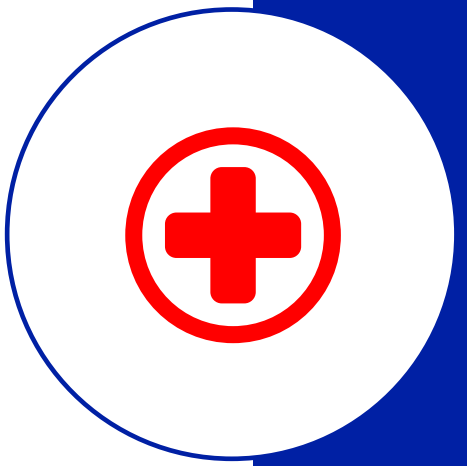
We need a field hospital now!

How can we arrange hospital beds and tents in a parking lot to make best use of the available space?

Planning Field Hospital Activity

1. Work in teams of 3 members.

2. Use the handouts provided.



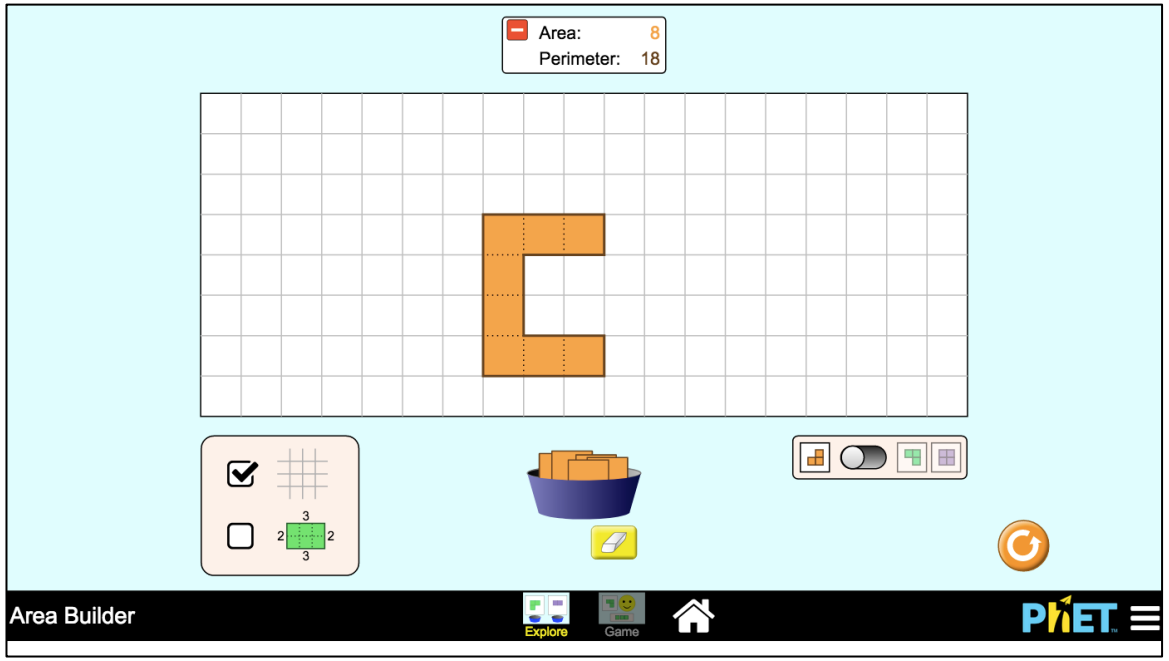
In-person download

Develop/Define

Perimeter & Area Simulation

Use of simulation for deeper conceptual understanding

https://phet.colorado.edu/en/simulation/area-builder



This stage can be taught using direct instruction to build understanding of the concept or through an activity:

- Build 2 different polygon shapes using the same number of tiles
- How did area and perimeter change as you changed the arrangement of the tiles?
- Is there a mathematical relationship that we can use to define area and perimeter?

Pandemic Field Hospital Background Reading

What is a Pandemic?
A Pandemic (Pan -dem-ic) is when there is a world-wide outbreak of a disease, usually a kind of virus. This virus can be a new type that people do not have an immunity for which means they can get sick and pass it onto others. This is how a virus can travel around the world.

What are Field Hospitals?
Field Hospitals are created during pandemics to be able to help the large numbers of people who are getting sick during a pandemic. Local hospitals and doctors can become crowded and field hospitals allow for more people who get sick to be treated.

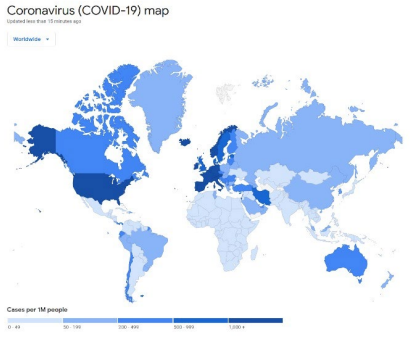


Figure 1:Covid 19 World Map (Wikipedia from World Health Organization Data), April 7, 2020

Field Hospitals are often built using tents placed in a large area like a parking lot or a field. Inside the tents are placed beds for the patients. Field Hospitals have to be able to be put together in many different ways based on the area of the tents, the space (perimeter) around the beds and the tents to prevent spread of the disease.

For this pandemic, the most common field tent size is 36 ft wide and 36 ft long, which is a square. The beds used for the field hospitals are 3 ft wide and 7 ft long. This holds most people who are normal size. Each bed has to be six feet away from the next bed. The beds have to be 2 ft from the wall and there has to be a 4 ft isle between the beds.

In emergencies, people like FEMA (Federal Emergency Management Agency), the Red Cross, or the National Guard set up the field hospitals. Sometimes church groups will set up field hospitals if needed. These hospitals can be set up in a matter of days and provide help to hospitals to care for patients during a pandemic.

Pandemic Field Hospital Inquiry Activity
Your Assignment:
You have been asked to set up a field hospital on a parking lot in town. Your job is to find the best way to set up the beds in the tents on your parking lot site according to the requirements listed in the background reading. After you find the best set up, you will be asked to fill out a report to the Red Cross on your plan.

You will work with a partner to complete this assignment. To help you, grid sheets have been provided where the grid squares are 1 ft wide and 1 ft long. You can use as many of these sheets as you need to solve your problem. There is a grid sheet for the tent and one for the parking lot.



Figure 2: Images of field hospital beds and tents set up in a parking area (Wikipedia)

Background Reading

- The background reading is in the handouts.
- Keep an eye out for important regulations for field hospitals.
- Feel free to highlight and annotate the document.

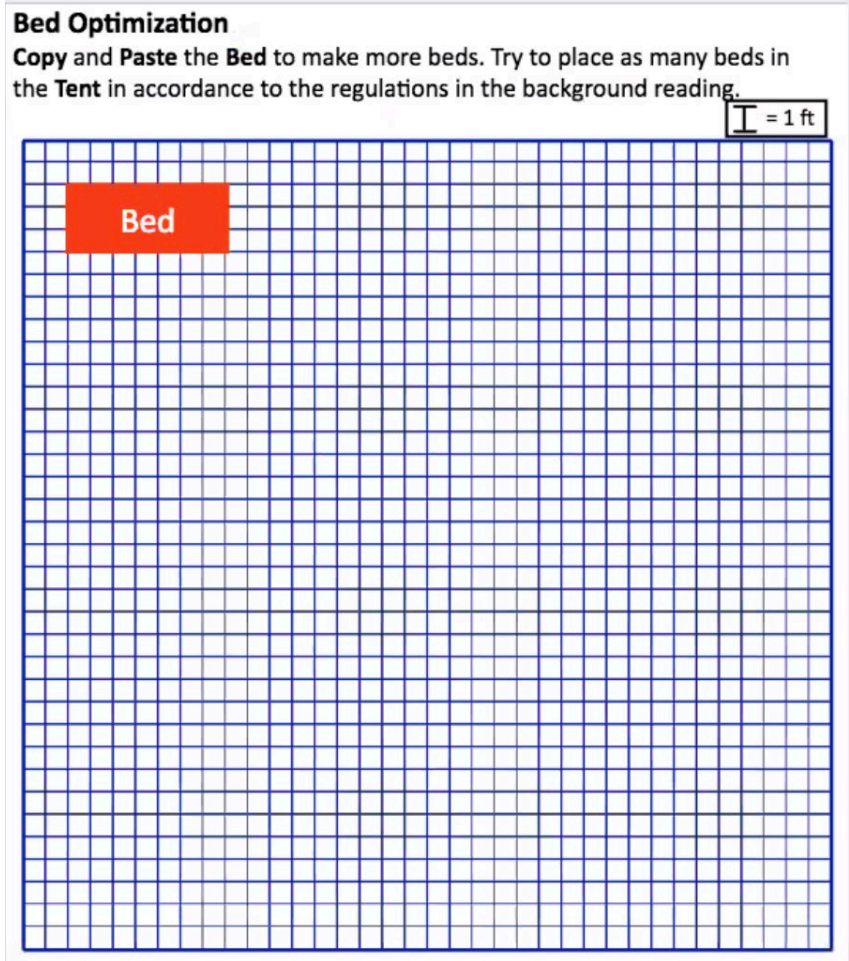
Develop/
Understand and Define

Planning Field Hospital Activity

In accordance with Red Cross regulations, we must figure out **how to maximize the beds in the field hospital tents**.

As a team:

1. Complete the Background Reading (pg. 6)
2. Maximize the beds in the field hospital tent (p.7)
3. Complete **Bed Optimization Data Sheets** for beds in tents optimization. (pg. 8)

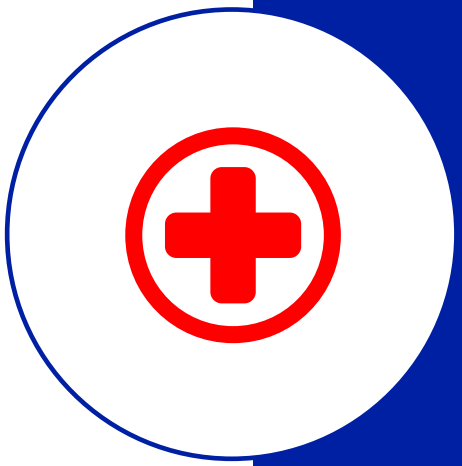


Deploy/Prototype & Test

Planning Field Hospital Activity

Share your group's Bed Optimization.

Bed



5 Minutes

Break

Present the product

Sample response letter to the Red Cross using framework as a guide.

Dear Red Cross

We are Group 3 and my teacher Dr. R asked our class to determine the optimum number of beds and tents for the pandemic hospital set up. Here is what my team determined based upon the specifications we were given.

As a team we analyzed the specific requirements to set up a tent with as many beds that could be allowed based on the specific dimensions and spacing. Each bed or quadrilateral covered a space with dimensions 3 x 7 feet. They must be 6 feet away from each other, 2 feet from the wall and a 4 feet aisle between beds. We tried moving the quadrilaterals (beds) vertically with the sides of the tent for optimal placement. They had to be 2 feet from each wall. We were able to position 15 beds in this manner. As a second option we placed the beds perpendicular to the outside wall of the tent. However, this did not change the number of beds allowed in the tent. We constructed 5 rows with 3 tents in each row. There was some confusion with aisles 4 feet between beds. We understood that the beds had to be 6 feet between each one, therefore how could there only be 4 feet aisles?

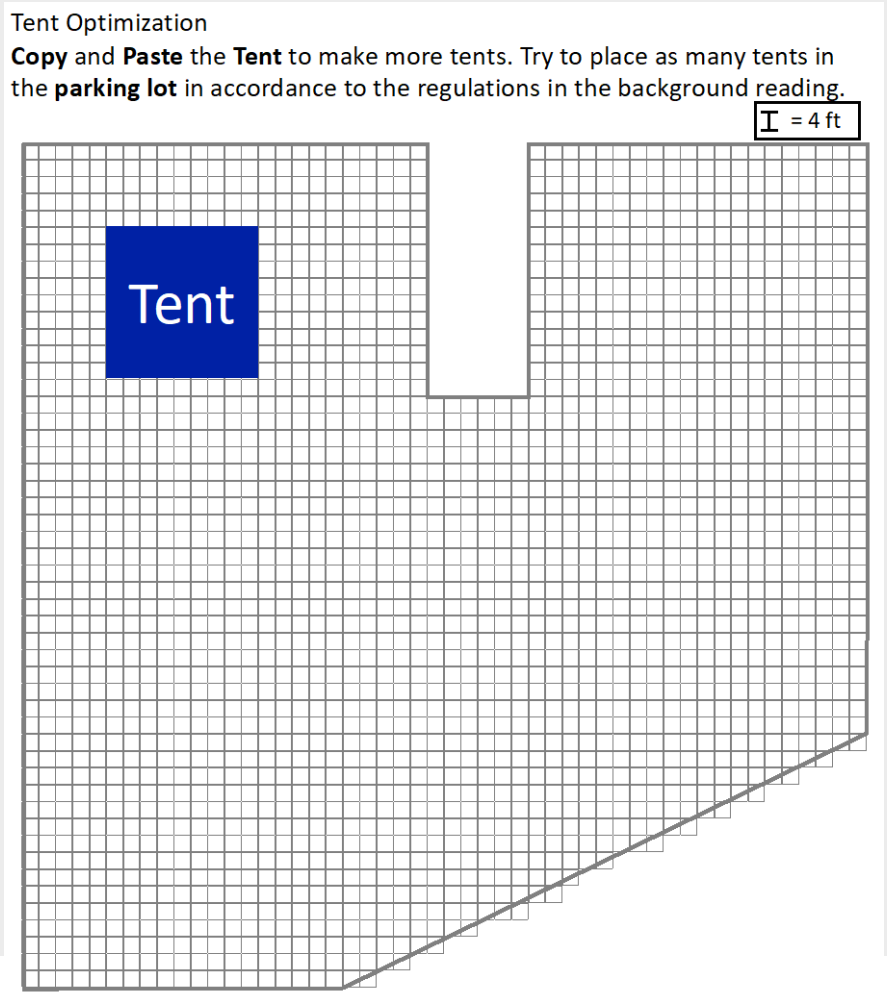
The placement of the tents to allow optimal location was very tricky. Each tent must be 20 feet from the edges of the field or parking lot. The tents are polygons that are 36 by 36 which is a perfect square. The reduced lower right corner of the field causes a reduction of the number of tents allowed due to the restrictions. We were able to fit 6 tents with the minimum distance between each tent. The right corner reduced the capacity for the parking lot to 6 tents. Therefore, our parking lot could hold six tents with 15 beds in each for a total of 90 beds in each parking lot. This completely restricts the number of patients that could be treated in each lot.
This is for normal size patients that could fit in each bed, so if someone unable to use a normal size bed the total patients to be treated would be reduced.

Thank you for all that you're doing to help and support the American people in a crisis.

Sincerely,

Group 3

Revisit, Refine, and Extend



- **Revisit and Refine** your model of what a footprint is. *Reflect on how your thinking changed.*
- A way to **Extend** the activity is to introduce arrange hospital tents in a parking lot.
- To further challenge students, you could change the shape of the tents or propose a different scenario.

EQuIPD Partner

Engaged Quality Instruction through Professional Development

UF Herbert Wertheim College of Engineering UNIVERSITY of FLORIDA

Inquiry Model Stages PD Analysis

The handouts provided outlines the following:

- **Purpose** of today's session activities
- What the **learner (you) was doing**
- What the **teacher (facilitators) was doing**
- How the activities support the respective **inquiry model and engineering design stage**

Use this document as a guide when designing your own lessons.

Elicit/Understand

Activities:	Purpose of Activities:
• Focus Question • Field Hospital Videos • “What is a footprint?”	>To elicit and engage prior knowledge >To identify students’ current conceptions and possible misconceptions.
What the learner was doing:	**What the teacher was doing:**
>Gathering background information about the scenario >Identifying what they do and do not know about the model or concept.	>Introducing the scenario and concepts >Asking questions to see what the students know or think about the concept/topic.

How do the activities in this inquiry model stage support the development of the conceptual model?

>They provide the students an opportunity to share what they already know about the model and or to develop some background knowledge about the concept if they don't have any.

Develop/Define

Activities:	Purpose of Activities:
• Build Model of Perimeter and Area • Perimeter and Area Simulation (PhET Labs) • Direct Instruction • Background Reading	>To expose students to the elements of the model that need to be developed to have a complete understanding of the concept.
What the learner was doing:	**What the teacher was doing:**
>Open to and testing new ideas >Forming new understandings of concept relationships >Collect, record, observe, and analyze data and information to develop a conceptual model	>Providing structured activities based on the conceptual model to allow students to explore, collect, and analyze information to build their model >Encourage collaborative learning >Observe and listen to students as they interact and share their ideas and understandings

How do the activities in this inquiry model stage support the development of the conceptual model?

>They provide the students an opportunity to explore new ideas and test their understanding to build a new understanding of a concept.

Deploy/Prototype and Test

Activities:	Purpose of Activities:

• Pandemic Field Hospital Activity
  • Regulations
  • Manipulatives: Beds
  • Optimization Data Sheets
  • Dear Red Cross Letter
	>To give students the opportunity to use and apply the conceptual model they have developed in a new application.

What the learner was doing:	**What the teacher was doing:**
>Testing the model in a new application or scenario >Use the model as a frame of reasoning when thinking and reasoning through questions while discussing with peers >Analyzing data and communicating understanding	>Creating activities to allow students to apply the model to real-world applications >Encourage discussion and reasoning with partners >Asks for justification and asks open ended questions

How do the activities in this inquiry model stage support the development of the conceptual model?

>They provide the students an opportunity to test and apply their conceptual models to a new scenario along with working and sharing their ideas with peers.

Refine

Activities:	Purpose of Activities:
• Revisit Perimeter and Area Model • Change shape of tents or parking lot • Propose a different scenario • Reflection on learning (Reflective Work)	>Provide opportunity to reflect on what they have learned and how their thinking may have changed >To adapt their model based upon the deployment of it in the real-world situation.
What the learner was doing:	**What the teacher was doing:**
>Reflecting on what they learned >Refining their model based upon how it performs in the real-world situation and correcting any discrepancies. >Testing their conceptual model in a new scenario	>Helping the students to understand models change when new information is presented, or old information is found to be obsolete. >Supporting students to reflect on their learning and understanding >Challenging students to test their understanding of a concept in a new scenario
How do the activities in this inquiry model stage support the development of the conceptual model?	
>They give the students an opportunity to reflect on how their thinking has changed after deploying the model in a real-world situation.	

- **Using the EQuIPD Lesson Design Framework provided, plan a lesson.**

EQuIPD Lesson Design Framework

Developing the Conceptual Model and Storyline

Project Title	
Identify the Standards	
Highlight Key/Core Ideas & Concepts	
Build the Model	
Develop Storyline	

Understanding the Problem

Real World Connection or Problem	
Focus Question	*Create focus question based in real world phenomena from design challenge*
Main Learning Goal	*Articulate what you want your students to understand by the end of the lesson series*

Devise a Plan – Staging the Lesson

Elicit *How will I engage students and elicit their ideas?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Develop *How will I get students to explore, explain and develop their ideas?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Deploy *How will I get students to use and apply their ideas to what they've learned?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Refine *How will I get students to extend, elaborate and change their ideas based upon what we now understand?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**

- **Using the EQuIPD Lesson Design Framework provided, plan a lesson.**

EQuIPD Lesson Design Framework

Developing the Conceptual Model and Storyline

Project Title	
Identify the Standards	
Highlight Key/Core Ideas & Concepts	
Build the Model	
Develop Storyline	

Understanding the Problem

Real World Connection or Problem	
Focus Question	*Create focus question based in real world phenomena from design challenge*
Main Learning Goal	*Articulate what you want your students to understand by the end of the lesson series*

Devise a Plan – Staging the Lesson

Elicit *How will I engage students and elicit their ideas?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Develop *How will I get students to explore, explain and develop their ideas?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Deploy *How will I get students to use and apply their ideas to what they've learned?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**
Refine *How will I get students to extend, elaborate and change their ideas based upon what we now understand?*			
Teacher Moves	**Student Moves**	**Questions/ Formative Assessments**	**Resources**

Improved Student Learning of Engineering Through Inquiry-Based Modeling Lessons Developed Using A System Thinking Perspective

Workshop Chairs

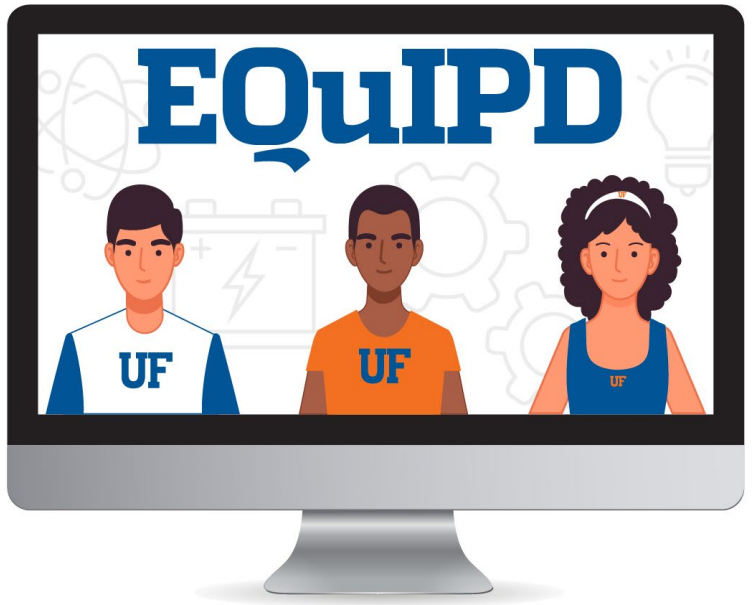
Dr. Nancy Jean Ruzycki

Dr. Krista Dulany

Dr. Lorelie Imperial

Florida Engineering Education Conference

February 25, 2022



Engaged Quality Instruction *through* **Professional Development**

UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Thank you for joining us!

If you have further questions send an email to: ***equipd@mse.ufl.edu***

To learn more about EQuIPD visit ***https://equipd.mse.ufl.edu/***