Building Conceptual Models and Engineering Design Thinking in K12 Students

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***Abstract*—This half-day workshop will engage participants in understanding how engineering design practices can be brought into core content classes to support conceptual model development in students as part of the model development cycle. Participants will have a chance to map this learning using frameworks developed by the facilitators.**

Keywords—Modeling instruction, system thinking, teacher professional development, computational thinking, engineering design

I. Background and Rationale

The growing concern for the shortage and quality of engineering graduates pursuing engineering-related careers has resulted in several revamps of the K-12 curriculum to include authentic engineering learning experiences. Engineering is now increasingly incorporated into US state standards, classroom experiences, instructional materials, and assessments [1]. K-12 classrooms are now including activities framed using the design process to teach authentic engineering: concepts, practices, and ways of thinking like professional engineers. Introducing engineering during the early years is viewed to influence students' decisions related to their career choice, which could address the problem regarding the inadequate pool of engineering graduates in many countries [2].

Making engineering education available to K–12 students within the US requires preparation and support for teachers who will be teaching engineering. The Engaged Quality Instruction Through Professional Development (EQuIPD) project supports teachers as they develop the capacity and build competency in creating and using conceptual models of the core content that they teach. EQuIPD is funded by the US Department of Education through the Supporting Effective Educator Development (SEED) program for Teacher Quality and is a teacher professional development grant. This grant serves 250 teachers in ten school districts in the state of Florida. Teachers and schools span rural, urban, and suburban districts, with about 2/3 of the teachers serving in schools with students who are designated as Low Socio-Economic Status or are students belonging to the underrepresented minorities as described by the US National Science Foundation. EQuIPD is designed as a randomized control study designed to meet What Works Clearing House (WWC) standards for design. EQuIPD has developed a scalable Engineering Design Thinking oriented lesson framework for teachers to support them with the use of modeling through the stages of model development cycle [3], [4].

Conceptual model development is an important aspect of teaching and is critical when designing learning experiences for students. Developing a concept model for the information will enable teachers to create a solid lesson framework from which to guide the lessons and activities. EQuIPD uses a model stages framework that has a learning cycle for "Elicit, Develop, Deploy and Refine" [3], which aligns to other inquiry frameworks such as the 5E model [5], and "Three Dimensional Learning" or Next Generation Science Standards [1]. The Modeling Instructional framework is attached in the Appendix. This framework is based on work in physics by Hestenes [6] and expanded over time by other researchers in science [7-13]. In addition to modeling instructional pedagogy, the grant brings in system thinking and design thinking to support teachers in professional development. System Thinking [14] comes from computational sciences and is a process method used to build knowledge. System thinking has recently gained interest in the field of education [15-16] to support conceptual model development in students. Design thinking is related to engineering design, with a focus on the end-user of the product or tool to be developed [17-18] and has also been utilized within teacher professional development as a tool for teachers to use to address "problems of practice." Within the EQuIPD grant, design thinking is taught to teachers as a tool for them to utilize in problem-solving, but also as a lesson activity for students to deploy and refine conceptual models through collaborative design experiences.

The conceptual model constructed for the EQuIPD grant illustrates how modeling, system thinking, and design thinking fit together for the professional development of teachers is shown in Figure 1 below.

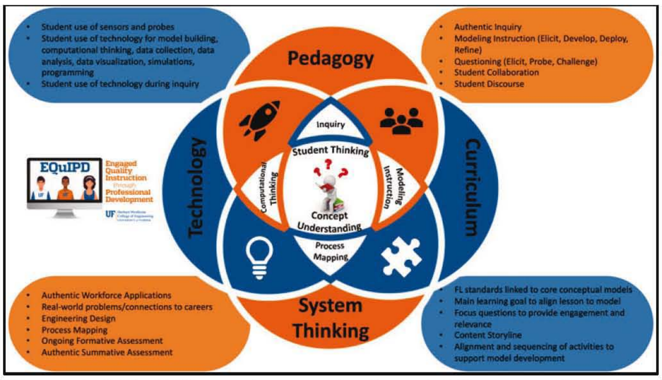


Figure 1: EQuIPD grant conceptual model for way of work

Using the conceptual model in Figure 1, grant teachers are trained on the individual parts of the model and supported in applying the model to "problems of practice" within their lessons through the guidance of facilitative coaches.

Teachers are encouraged to utilize technology (including sensors, probeware) to help students build visual models for phenomena quickly and accurately. Teachers are also trained in the appropriate use of technology as a tool for conceptual understanding for both sensors and probes, but also educational technology, including simulations, collaborative documents, and teacher tools (Nearpod, Plickers, Kahoot, Peardeck, FlipGrid) to assess and engage students within a lesson. The goals for this grant are aligned with the 2017 European Framework for the Digital Competence of Educators, which argues for teacher fluency with education technology to support students in the learning process.

By placing the core focus on developing the conceptual model they will be teaching, teachers can develop lessons that are streamlined and targeted to the concept. This modeling process helps them avoid incorporating activities that take up time but are not targeting developing students' conceptual understanding. We argue for the use of models for concept development as a framework for lesson design. Modeling will push teachers to ensure self-understanding of the concepts, develop a lesson to ensure instruction of these concepts and, as a result, improve students' learning. This will, however, generate significant challenges for teachers as they modify the ways they design and teach their lessons to facilitate students' deeper understanding. Helping teachers utilize modeling as a concept development approach will require a new professional development approach.

II. FACILITATORS

A. *Main Presentors*

Dr. Nancy Ruzycki holds a PhD in Physics from Tulane University, is a certified teacher, and holds National Board Certification in Physics. She is a "Modeler" and has trained at Florida International University for Modeling Physics. She teaches at the University of Florida and conducts research on engineering education and the use of models, process maps, and system thinking in teaching. She has received over 5 million US dollars in grant funding in the past three years and is the Principal Investigator on the EQuIPD grant.

Dr. Lorelie Imperial holds a PhD in Curriculum and Instruction - Science Education from the University of Florida and is currently a post-doc for the EQuIPD grant. She specializes in conceptual model development and how to incorporate models into lessons. She also specializes in teaching Chemistry.

B. *Supporting Presentors*

Coaches Dr. Krista Dulany, Jared Carter, Seleka Naomi Kerr, Christine Angel Danger and Leigh Arnold are Instructional Coaches on the EQuIPD grant and work as facilitative coaches for teachers in the grant. They have created multiple frameworks for use with teachers to develop lessons that build conceptual models in students.

III. WHAT PARTICIPANTS GAIN FROM THIS SESSION

From attending this workshop, the participants will be able to achieve the following:

A: Identify the Core Content Model for lesson use.

B: Understand how the development of a storyline and process map with swim lanes aid in developing and staging activities within a lesson.

C. Understand the model development stages, which comprise conceptual model development.

D: Understand the role of engineering design in the model development cycle.

E: Understand how design thinking and engineering design provide relevance for students and can be localized and personalized for the student demographics.

F. Participate in using the frameworks and tools presented to build out their own lesson incorporating engineering design thinking.

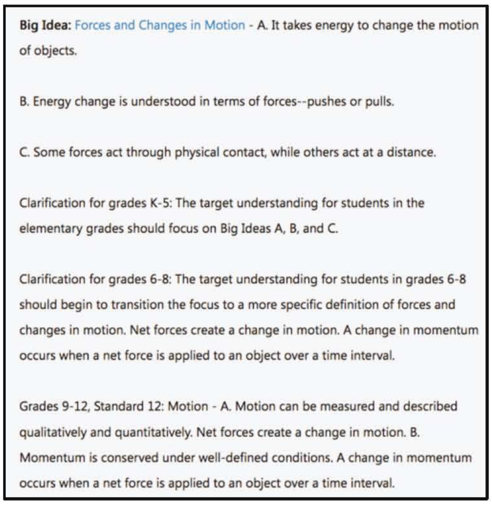
IV. PARTICIPANT ENGAGEMENT

Participants will be engaged in collaborative, hands-on activities during each stage of the session. They will work through the workshop activities either in a face-to-face or virtual format. After the eliciting and developing stages, participants will go into small groups or breakout rooms to deploy the workshop findings into their own work. Participants will come back together at the end to receive feedback to refine their lessons or outcomes.

IV. A-B IDENTIFYING CORE CONTENT MODELS

Being able to identify the concept they are going to teach, analyze state, regional, or governmental standards, and break standards down into the important conceptual elements, teachers are themselves developing the ability to identify what it is they understand about a concept. For example, we can examine the concept model for *Force and Motion*, which can be found in curriculum worldwide [20] but may have different areas of focus and depth from country to country. In Spain, the elementary science curriculum has a focus on "matter and energy" and "objects, machines, and technology;" within these broad categories, force and motion concepts exist [20]. In South Africa, Force and Motion may be included in the primary grades in terms of "energy and change" but are not explicitly developed until middle school [21-22]. Whereas in Kazakhstan, by the end of Grade 9, students should have acquired knowledge of motion [20].

Below is an image of a model for *Force and Motion* for an elementary teacher and a middle school teacher within two different school systems in the state of Florida in the United States. The Florida standards for Force and Motion are as follows, Figure 2. [23]:



Big Idea: Forces and Changes in Motion - A. It takes energy to change the motion of objects.

B. Energy change is understood in terms of forces--pushes or pulls.

C. Some forces act through physical contact, while others act at a distance.

Clarification for grades K-5: The target understanding for students in the elementary grades should focus on Big Ideas A, B, and C.

Clarification for grades 6-8: The target understanding for students in grades 6-8 should begin to transition the focus to a more specific definition of forces and changes in motion. Net forces create a change in motion. A change in momentum occurs when a net force is applied to an object over a time interval.

Grades 9-12, Standard 12: Motion - A. Motion can be measured and described qualitatively and quantitatively. Net forces create a change in motion. B. Momentum is conserved under well-defined conditions. A change in momentum occurs when a net force is applied to an object over a time interval.

Figure 2: Florida Standards for *Force and Motion*

Figure 3 is an example of a teacher first approach to developing a model of the content elements which go into a model for *Force and Motion* using the standards as a guide. While standards "point" to a model, they are not models, and teachers have to recognize or develop a model using the standards.

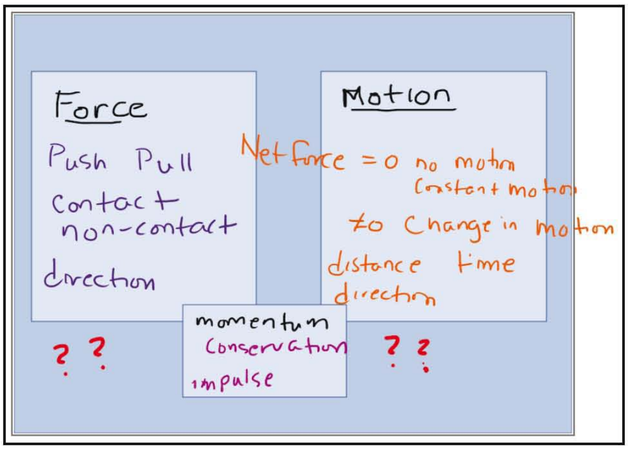


Figure 3: Teacher first approach for *Force and Motion* model

Once the teacher has developed the model, they will organize the information presented in the model into the order in which the information will be taught to students. Model development sets up the staging of the activities and leads to creating the model storyline - a verbal representation of the development of the model. Figure 4 is an example of a model developed by an elementary teacher.

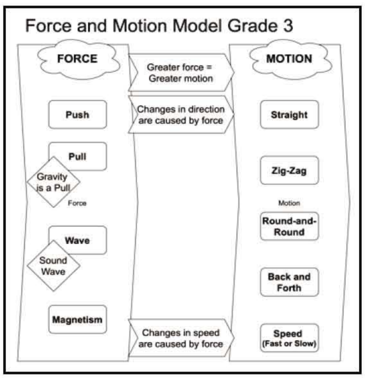


Figure 4: Lower grade teacher model for *Force and Motion* model.

The model developed by this teacher includes aspects for the motion of waves and magnetism, which are related sub-standards included by the district in the teacher's pacing guide. The storyline the teacher developed for her students for this model is shown in Figure 5. They show the way in which the teacher will stage the lesson for conceptual development. Once the teacher has the storyline mapped out, they then create a lesson using the modeling stages to build out this conceptual model in students through a series of engaging activities.

Forces are things we call pushes and pulls. Gravity is considered a pull force. There are other forces that can push or pull like waves or magnets. Some of these forces act through contact with an object and some forces act on an object without touching it. Gravity and Magnetism are forces that act without touching an object. Sound waves cannot be seen, but they work by pushing air out in front of them and act on your ear to vibrate the ear drum and create sound. Forces can cause an object to move or to change the way it moves, or the direction it moves. Motion is the way an object moves. Objects can move in different ways or directions including straight, up/down, zig zag, round and round, back and forth. How fast an object moves is called speed. Greater forces can cause a larger change in the motion of the object. Forces can make an object start to move or stop moving.

Figure 5. Lower school storyline for *Force and Motion* Model.

IV. C. UNDERSTANDING MODEL LESSON STAGES

After teachers have developed a model and a storyline, they create a lesson using precepts from the model stages. Below is a Table for a framework utilized by teachers for the model stages. The framework is presented in "swim lanes," a process mapping method to show what each "actor" is doing during the process. In this case, what the teachers and students are doing during the lesson.

Table 1: Modeling Instructional Stages

Stage and Purpose	What the Learner is Doing	What the Teacher is Doing
Elicitation The purpose of the elicit stage is to elicit and engage prior knowledge related to the learning goal/model, as well as to check in as to where the learner is in the development of the model. The prompts, questions, scenarios, or activities associated with this phase should orient the learners to the purpose of the lesson and help them understand the relevance for the learning.	• Answers questions such as "What did you observe?" "What do I already know about this topic?", "How or why does this act or behave this way?" Shows interest in topic. • Identifies what information they know and do not know about the phenomena or model. • Identifies or begins to identify a phenomenon, concept, or problem to be explained.	• Creates interest and generates curiosity through a phenomenon related to the model. • Asks eliciting questions to uncover what the students know or think about the concept/topic. • Helps students identify or begin to identify the phenomenon, concept, or pattern to be explained. • Helps students understand what they do not know in relation to the model which has to be explored or understood to develop the model.
Development The purpose of the development stage is for students to have experiences with elements of the model which need to be developed based on feedback from the elicit stage. Development is focused on element concepts which lead to a complete understanding of the model. This is a time to make visible the thinking of learners, to develop and use physical representations, to analyze, collect and interpret information and observations, and to make connections between the ideas and the activity. By the end of the development, students will have a model composed of the elements based on their experiences.	• Developing a model based on the elements contained within the model, and appropriate to the level of the students. • Thinks freely, but within the limits of the activity. • Tests ideas and predictions about the phenomenon, concept, or problem to be explained • Forms new ideas, and confronts old ideas using information from experiences during development in order to create a model. • Tries alternatives and discusses them with others in a collaborative and supportive environment. • Collects, records observations and ideas, and uses information to develop a model • Remains open to ideas and information in order to develop a model	• Creates a structured set of activities based on model elements to allow students to collect and analyze information in order to build a model. • Encourages the students to work together collaboratively, ideally without direct instruction from the teacher • Observes and listens to the students as they interact in order to understand student thinking and identify misconceptions which will be addressed by the activities • Asks probing questions to help students internalize and manage conflict from old and new ideas. • Redirects students when necessary to maintain focus on the concept element(s) being developed. • Provides time for students to puzzle through problems and resolve development of the model • Acts as a consultant for students to support the model development.
Deployment The purpose of the deployment stage is to provide learners an opportunity to use the model they have developed and apply it a new application to extend the model to a real work application. Learners are provided with opportunities to reflect on what they have learned and to consider how their thinking may have changed and what constraints the model may have in application.	• Tests the model out in a new application or situation. • Using the model as a frame for reasoning, explains possible solutions or answers to others. • Listens critically to others' explanations and poses questions to others around the constraints of the model. • Uses reasoning from development to apply and extend the model in new situations. • Refers to previous activities and uses recorded observations or data in explanations to identify constraints or limits of the model. • Reflects on their own progress, knowledge, and kinds of thinking they engaged in during the whole experience • Communicates orally and in writing the application of the model and ability of the model for real world applications.	• Creates activities to allow students to use the model in a real-world situation. • Encourages the students to explain model concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally provides definitions, explanations, and new labels • Uses students' previous experiences as a basis for explaining concepts and considering limitations of the model • Asks open ended questions such as Why do you think…? What evidence do you have? "How well does this model explain…?", "How can this model be used to ….?, How does this model help us answer the question….? "Would this model work when….?" • X? • Allow students to assess their own learning and group processing skills in relation to the model
Refinement The purpose of the refinement stage is to adapt the model based the deployment of the model in a real-world situation.	• Students look at how well the model performs in a real-world situation, and then refine the model if needed to account for discrepancies with the model they developed and what they experienced in the real-world application. • Students discuss the constraints of the model and the model limits. • Students develop a more appropriate model for the content. • Students reconcile the model they have refined versus their initial understanding of the model. • Students communicate the model in multiple ways.	• Allows students to work through the model cycle and allow for reflection on "First I thought…., now I think…." • Creates activities allowing students to share the refined model in multiple ways of communication (oral, written, video, pictorial) • Helps students to understand models are representations which can grow and change when new information is presented, or old information is no longer relevant.

During each model development stage, the teacher designs instruction to guide students through the storyline to ensure conceptual development. Currently, teachers spend most of the lesson in the development stage focused on direct instruction. Teachers are reminded that they need to move students through all stages of the model development cycle to develop a complete conceptual model. To assist teachers with lesson development, the EQuIPD grant has created a Model Lesson framework located in the Appendix.

IV. D-E ENGINEERING DESIGN AND DESIGN THINKING

The EQuIPD grant uses the Design Thinking framework from Stanford University [17], which aligns well with research from Dym [24], the K12 Engineering Education framework from Perdue University [25], and the American Society for Engineering Education (ASEE) P12 framework [26]. From a modeling instructional practices framework, the key purpose of design thinking and engineering design within a lesson is to support the deployment and refinement of the conceptual model. Students deepen their understanding of how the model works in application. To introduce and train teachers on design thinking, the grant brings the teachers through a design experience to help teachers understand that design is a process that can fit within all content areas. For example, during a spring 2020 training, teachers were introduced to engineering design in the context of a lesson on area and perimeter in mathematics. Teachers had a background reading, Federal Regulations for field hospitals, and worked through the activities for the design process in a collaborative team. Figure 6a) is the interactive activity to place pandemic field hospital beds within a tent, and b) the design process and calculations to be completed during the design activity.

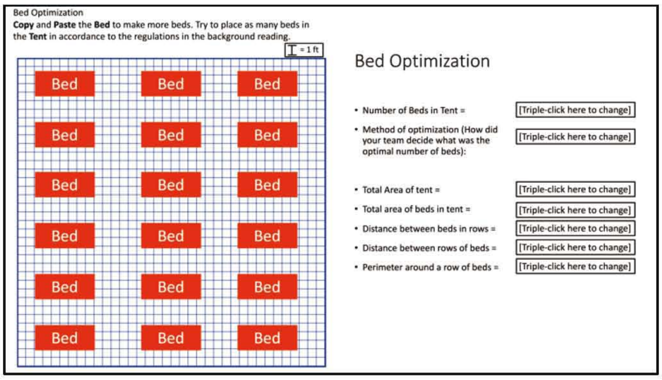


Figure 6: Pandemic Field Hospital Activity for Engineering Design. a) grid for placement of beds b) placement optimization and math connection.

As teachers work through the activity, they learn about the parts and purposes of the design activity and understand how they work together to build, expand and refine a conceptual model for students. Engineering design activities like this one can provide relevance for applying the concept to real-world and place-based problem-solving. Additionally, teachers receive a rubric for the activity and understand how rubrics can be used to guide the learner in the design activity. Figure 7 shows the rubric for use with the activity.

Activity part	Reasoning	Math	Communication
Individual and group Beds in tent optimization	Did I place all of the beds in the tent in a way that has the maximum number of beds? Did I try different ways to place the beds to see which was the most efficient? Did I leave walkways for people and equipment to move through? Did I use or see patterns which were helpful in optimizing the number of beds in a tent?	Did I use the requirements for spacing for the perimeters that had to be around each bed? Did I figure out the area of the tent? Did I figure out the area of each bed? Did I find the total area of all the beds in the tent? Did I use math in my discussion with partners about how to best arrange beds to optimize the number of beds in a tent? Did I use equations to help me determine perimeter and area?	Did I write down the method I used to optimize my beds in the tent? Did I write down all of the ways I tried to arrange the beds? Did I communicate my ideas to my partners during the team portion? Did I listen and consider the ideas of others for ways to arrange beds in tents? Did I save a copy of my individual layout of beds and my group layout of beds so I can use them later in discussions?
Group Optimization of tents in parking lot	Did I look at the shape of my parking lot and recognize the polygon shape? Did I think about the shape and any features that would make it more difficult to optimize the number of tents?	Did I use the requirements for spacing for the perimeters that had to be around each tent, and the requirements for how far the tents have to be from the edges of the parking lot? Did I figure out the area of the parking lot? If all the space is not usable, did I figure out how much area was not able to be used and mark it on my diagram? Did I figure out the area of each tent? Did I find the total area of all the tents in the parking lot? Did I use math in my discussion with partners about how to best arrange tents to optimize the number of tents in the parking lot.? Did I use equations to help me determine perimeter and area?	Did I write down the method I used to optimize tents in the parking lot? Did I write down all of the ways I think would work to optimize the tents in the parking lot?? Did I communicate my ideas to my partners? Did I listen and consider the ideas of others for ways to arrange tents in the parking lot? Did I support my position using my reasoning and mathematics? Did I save a copy of my group layout of tents for use them later in discussions? Did I write down any issues with the optimization that was related to the shape of the parking lot?
Writing a Summary Letter to FEMA	Did I explain my reasoning for the layout? Did I explain any issues related to the shape of the parking lots that made the optimization of tents less efficient?	Did I use my mathematical findings to support my claims in my reasoning? Did I use mathematical statement to explain how I knew this arrangement was the most optimized?	Did I use disciplinary specific language to help support my mathematical ideas and reasoning in the letter? Did I construct proper sentences?

Figure 7. Pandemic Field Hospital Rubric for use in the Pandemic Field Hospital design activity.

Teachers are invited to think about how design activities can be used within time-constrained classrooms to allow students to engage in meaningful engineering design and design thinking experiences tied to the lesson concept, rather than one-off engineering design activities.

IV. F. BUILDING LESSONS USING FRAMEWORKS

During the workshop, teachers are encouraged to assess existing lessons or provided curriculum to see how these existing lessons develop the content model. Once the concept model for the existing lesson is mapped, missing concept elements must be identified and included in the lesson. Teachers then reorganize and stage the lesson through activities and direct instruction using the modeling instructional stages. Engineering and Design thinking activities are encouraged for the deployment and refinement stages of the lesson as a natural application for core content and to provide authentic and relevant engineering and design activities. Design lesson frameworks are provided to teachers, and teachers are developing a process map for their lessons. Figure 8 is an example process map for a teacher's lesson on climate change. Here the teacher has included swim lanes for what the teacher is doing, what the teacher and students do together during guided activities, and what students will do independently. Using a framework or process map helps the teacher understand the process they will use to teach the concept and focus on lesson components that build the model. An additional example is included in the Appendix.

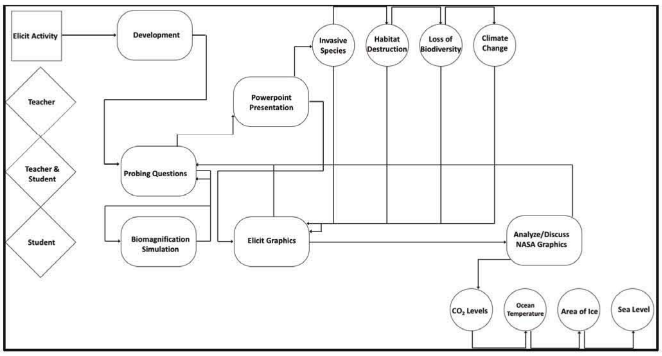


Figure 8: Teacher-generated process map for staging a lesson on climate change for middle school students.

V. SUMMARY

The EQuIPD grant utilizes system thinking, modeling instructional pedagogical practices, design thinking, and engineering design to assist teachers in developing lessons that support students to build conceptual models. The significance for engineering education is that participants will understand the importance of conceptual model development in students and the role that engineering design can play in helping to build and refine core concept models in students.

The participants will receive all frameworks and handouts from the session and will receive a link to a TEAMS site to find these and other supporting documents, which are also included in the Appendix. Participants will be encouraged to post their lessons and questions to this TEAMS site which the grant coaches and post-doc will monitor.

No special assistance is needed for the workshop.

ACKNOWLEDGMENT

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Appendix A

EQUIPD MODELING INSTRUCTIONAL FRAMEWORK

<table>
<tr><th>Stage and Purpose</th><th>What the Learner is Doing</th><th>What the Teacher is Doing</th></tr>
<tr><td>Elicitation
The purpose of the elicit stage is to elicit and engage prior knowledge related to the learning goal/model, as well as to check in as to where the learner is in the development of the model. The prompts, questions, scenarios, or activities associated with this phase should orient the learners to the purpose of the lesson and help them understand the relevance for the learning.</td><td>Answers questions such as “What did you observe?” “What do I already know about this topic?”, “How or why does this act or behave this way?” Shows interest in topic.
Identifies what information they know and do not know about the phenomena or model.
Identifies or begins to identify a phenomenon, concept, or problem to be explained.</td><td>Creates interest and generates curiosity through a phenomenon related to the model.
Asks eliciting questions to uncover what the students know or think about the concept/topic.
Helps students identify or begin to identify the phenomenon, concept, or pattern to be explained.
Helps students understand what they do not know in relation to the model which has to be explored or understood to develop the model.</td></tr>
<tr><td>Development
The purpose of the development stage is for students to have experiences with elements of the model which need to be developed based on feedback from the elicit stage. Development is focused on element concepts which lead to a complete understanding of the model. This is a time to make visible the thinking of learners, to develop and use physical representations, to analyze, collect and interpret information and observations, and to make connections between the ideas and the activity. By the end of the development, students will have a model composed of the elements based on their experiences.</td><td>Developing a model based on the elements contained within the model, and appropriate to the level of the students.
Thinks freely, but within the limits of the activity.
Tests ideas and predictions about the phenomenon, concept, or problem to be explained
Forms new ideas, and confronts old ideas using information from experiences during development in order to create a model.
Tries alternatives and discusses them with others in a collaborative and supportive environment.
Collects, records observations and ideas, and uses information to develop a model
Remains open to ideas and information in order to develop a model</td><td>Creates a structured set of activities based on model elements to allow students to collect and analyze information in order to build a model.
Encourages the students to work together collaboratively, ideally without direct instruction from the teacher
Observes and listens to the students as they interact in order to understand student thinking and identify misconceptions which will be addressed by the activities
Asks probing questions to help students internalize and manage conflict from old and new ideas.
Redirects students when necessary to maintain focus on the concept element(s) being developed.
Provides time for students to puzzle through problems and resolve development of the model
Acts as a consultant for students to support the model development.</td></tr>
<tr><td>Deployment
The purpose of the deployment stage is to provide learners an opportunity to use the model they have developed and apply it a new application to extend the model to a real work application. Learners are provided with opportunities to reflect on what they have learned and to consider how their thinking may have changed and what constraints the model may have in application.</td><td>Tests the model out in a new application or situation.
Using the model as a frame for reasoning, explains possible solutions or answers to others.
Listens critically to others’ explanations and poses questions to others around the constraints of the model.
Uses reasoning from development to apply and extend the model in new situations.
Refers to previous activities and uses recorded observations or data in explanations to identify constraints or limits of the model.
Reflects on their own progress, knowledge, and kinds of thinking they engaged in during the whole experience
Communicates orally and in writing the application of the model and ability of the model for real world applications.</td><td>Creates activities to allow students to use the model in a real-world situation.
Encourages the students to explain model concepts and definitions in their own words
Asks for justification (evidence) and clarification from students
Formally provides definitions, explanations, and new labels
Uses students’ previous experiences as a basis for explaining concepts and considering limitations of the model
Asks open ended questions such as Why do you think…? What evidence do you have? “How well does this model explain…?”, “How can this model be used to ….?, How does this model help us answer the question….? “Would this model work when….?”
X?
Allow students to assess their own learning and group processing skills in relation to the model</td></tr>
<tr><td>Refinement
The purpose of the refinement stage is to adapt the model based the deployment of the model in a real-world situation.</td><td>Students look at how well the model performs in a real-world situation, and then refine the model if needed to account for discrepancies with the model they developed and what they experienced in the real-world application.
Students discuss the constraints of the model and the model limits.
Students develop a more appropriate model for the content.
Students reconcile the model they have refined versus their initial understanding of the model.
Students communicate the model in multiple ways.</td><td>Allows students to work through the model cycle and allow for reflection on “First I thought…., now I think….”
Creates activities allowing students to share the refined model in multiple ways of communication (oral, written, video, pictorial)
Helps students to understand models are representations which can grow and change when new information is presented, or old information is no longer relevant.</td></tr>
</table>

Appendix B

ENGINEERING DESIGN THINKING LESSON 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	
Main Learning Goal	

Devise a Plan – Staging the Lesson
How does design thinking connect to the Inquiry Model Stages?
Resources: Discussion Protocols, Workforce Skills, Real-World Connections, Technology

Empathize How do your students connect with the audience or the user of the design?		
Teacher Moves	**Questions/Formative Assessments**	**Resources**
Define Identify what the focus of the design is from the information gathered in the empathize stage.		
Teacher Moves	**Questions/Formative Assessments**	**Resources**
Ideate How will you support your students to brainstorm design ideas?		
Teacher Moves	**Questions/Formative Assessments**	**Resources**
Prototype Build or sketch your ideas to see if they meets the needs of your audience or user.		
Teacher Moves	**Questions/Formative Assessments**	**Resources**
Test Share your designs with peers and the audience/user for feedback and refinements.		
Teacher Moves	**Questions/Formative Assessments**	**Resources**