



Innovative Engineers

by

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4th & 5th grade

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Introduction

Rationale

The intent of this unit is to allow students to explore the concept of innovation while learning and utilizing content across various disciplines. Innovation influences every facet of life, therefore students can identify with it on multiple levels. This opportunity for students to be able to understand, recognize, practice, and explore innovation especially in the realm of engineering is of great value because it continually requires students to utilize higher level thinking skills. Innovation is not just about coming up with new ideas, which involves creating, but also requires that those designs are an improvement upon those that came before or they meet a specific need. To innovate one must be continually involved in the processes of judging the value of a new design and weighing its pros and cons. One must justify how the design fulfills a purpose in a more efficient, cost effective, safe, specific, or broad way. The essential understanding for students to learn is that “purpose influences innovation”. Looking at innovation from this understanding, students will see that problems or needs give us purpose. Innovation is how these problems are solved.

Since innovation can involve any discipline, students can explore their own interests and will incorporate content from across disciplines. In this unit students will learn and apply concepts as they are needed for the challenges they face. Engineering involves utilizing math and science to solve real world problems. Students will learn new math, science, and even social studies content to be able to budget for, develop, and construct innovative engineering designs during these lessons. The lesson models used also give students opportunities to develop advanced process skills such as evaluating, inferencing, and critical thinking. The process of collaboration is also emphasized throughout this unit.

Ultimately, the goals of this unit are important because they are key to students becoming problem solvers. A student that can creatively work through problems by utilizing high level processing skills while appropriately applying content skills will be able to handle challenges throughout life. This along with encouraging curiosity and creativity will inspire lifelong learning.

Population and Differentiation for Gifted Learners

The lessons in this unit were created for the purpose of teaching rising fourth and fifth grade gifted students (nine and ten year olds) at a four day long enrichment camp for approximately three hours a day. Though all the students attend school in the same county, the dynamics of the population could vary greatly. Students from the inner city, suburban and rural areas were all invited to participate as long as they were gifted. Their socioeconomic background and achievement levels in school were unknown to me due to the short time working with them and may have varied greatly. Though students came from a wide range of backgrounds there were some consistencies within the classroom that were observed throughout the week. I will address these consistencies as to how they relate to the differentiation that was used within the unit.

Content

These students had working understanding of the math and science content from their previous grades. Students did not need to review the content that they needed for the lessons, though I was prepared to do so. Many of the students had further knowledge of content that they had learned on their own. Without accelerating to above grade level curriculum, these students would not have been challenged. Because the knowledge was appropriate and needed for the tasks at hand, students learned and excelled in applying and analyzing the new seventh grade math and science content. Students were able to increase complexity through integration of multiple disciplines using both old and new learning. They explored the language of the discipline of innovators and engineers, identified patterns in innovating, and explored unanswered questions to increase depth.

Process

The advanced ability of the students in this class matched well with the challenging lesson models that were used in this unit. Students participated in a Socratic Seminar that required students to formulate unanswered questions that could be discussed at a high level of understanding. The seminar was student led requiring students to listen and process the discussion. Students then built on others' ideas or constructed their own position statements that they shared with the group using evidence to support clear statements. Students then participated in a simulation that required an advanced level of concepts to make necessary adjustments to continue to build with available resource. Multiple disciplines were integrated and students had to handle multiple tasks simultaneously with added to the complexity. A Visual Thinking Strategy lesson gave students the opportunity to use higher-level processing skills including analyzing, inferring, speculating, empathizing, and interpreting images to create understanding of various photographs. Both a Creative Problem Solving lesson and the performance task gave students the opportunity to grow through alternating use of divergent and convergent thinking. Through all of these lessons students had the opportunity to exercise their creative abilities to interpret, problem solve, design, and construct. They also have multiple opportunities to reflect and self-evaluate their actions and thought processes during the innovative experience.

Product

These lessons allowed differentiation in the products based on each student's interests and abilities. During the Socratic Seminar student answers and insight varied according to the abilities of each student. Some showed great leadership and social abilities, while others focused on their own thoughts and what they wanted to share. Students did incorporate what they knew as well as in-depth questioning into the conversation and their written answers. The student products during the lessons varied according to the various intellectual and social abilities of those in each group. This was beneficial for allowing gifted learners to incorporate what they knew into the product while allowing them to grow through exploration, creativity, and innovation. The student produced captions during the VTS lesson varied according to the various abilities, depth of understanding, and learning styles. There were a few students who wrote very little, but were able to verbally share mature and insightful explanations. The performance task allowed for differentiation by giving students choice and freedom to pursue their interests and creative ideas.

Learning Environment

The learning environment of the whole class was differentiated because the entire class was a cluster of gifted learners. It was a small class of only sixteen students. This homogeneous grouping of gifted students gave students the opportunity to work with likeminded peers with similar abilities who challenged each other to higher understandings and possibilities. Students worked in various group settings including whole class, small collaborative groups, and independent work. The use of multiple types of grouping allowed all students to have the opportunity to work in their preferred environment. It also provided the opportunity for students to be challenged to cooperate, learn, and produce in a group environment that may not be one that they feel confident in.

Goals and Outcomes

Content Goals and Outcomes

Goal 1: To develop understanding and appropriately use scientific principles related to force and motion to evaluate and create innovative designs.

Students will be able to...

- A. Apply understanding of how factors such as gravity, friction, compression, tension, and change in mass affect the motion of objects and can be used in real-world designs.
- B. Predict the effect of a given force or a change in mass on the motion of an object.
- C. Explain the effects of balanced and unbalanced forces acting on an object and use that knowledge to increase stability in structure and designs.

Goal 2: To develop understanding and appropriately use mathematical principles to budget for, create, and evaluate innovative designs.

Students will be able to...

- A. Determine budgets and prices when there is a percent increase or decrease.
- B. Apply geometric principles of shapes and angles to design, construct, and evaluate designs.
- C. Convert among different-sized standard measurement units within a given measurement system and use these conversions in solving multi-step, real world problems.

Goal 3: To understand the relationship between a market economy, economic factors, and purpose for innovation.

Students will be able to...

- A. Explain how scarcity or abundance of financial resources affects the choices people make based on their wants and needs.
- B. Describe how the basic concepts of a market economy such as price, supply, demand, and scarcity influenced their decisions and innovations in design.
- C. Show understanding of how scarcity and choice in a market economy impact business decisions during simulation experience.

Process Goals and Outcomes

Goal 4: To develop collaboration skills.

Students will be able to...

- A. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) building on others' ideas and expressing their own clearly.
- B. Disagree with positions and reasoning of others in a positive, productive manner.
- C. Construct viable arguments and critique the reasoning of others
- D. Build on other's ideas and grow in his or her own understanding

Goal 5: To develop evaluation skills.

Students will be able to...

- A. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.
- B. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence.
- C. Evaluate solutions to artistic problems, including their effectiveness.
- D. Construct viable position statements and give evidence to support these statements

Goal 6: To develop critical thinking skills.

Students will be able to...

- A. Creatively and critically analyze artistic expression.
- B. Develop open ended higher level thinking questions.
- C. Synthesize and analyze information from multiple sources (visual, written, and verbal) to increase understanding, make connections, and develop original ideas.
- D. Analyze the purpose and operation of innovations and predict possible hindrances of the design.
- E. Judge the value of an innovation.
- F. Analyze problems and persevere in solving them through observation, clue-finding, drawing conclusions, and innovation.
- G. Reflect on and self-evaluate their actions and thought processes during the innovative experience.

Goal 7: To develop inferencing skills.

Students will be able to...

- A. Interpret details and expression to infer meaning
- B. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a text based on specific information in the text.
- C. Support and explain inferences drawn from a text with use of appropriate text quotes, details, and examples that support the inference.
- D. Infer meaning from art by interpreting the image and the story that it tells.
- E. Infer cause and effect throughout design and building of engineering innovations.
- F. Make inferences as to the circumstance that lead to the capturing of a picture.

Concept Goals and Outcomes

Goal 8: To understand the concept of innovation in relation to engineering.

Students will be able to...

- A. Recognize that the job of an engineer is to use math and science in designs and creations that help solve real-world problems
- B. Understand that innovation involves ideas that are new and valuable, that there is value in unsuccessful attempts at innovations, and that innovation and engineering do not always coincide.
- C. Explain how problems create purpose.
- D. Distinguish the influence that purpose has on innovation in general, particular innovations, and in their own engineering innovations.
- E. Create an innovation by developing an original idea or an improvement on someone else's design.
- F. Successfully respond to problems and changes in resources while fulfilling purpose by exhibiting innovation, flexibility, and stamina in problem-solving.
- G. Apply concepts from science and math to engineering innovations.
- H. Apply understanding of innovation and how purpose influences innovation to understanding of pictures.
- I. Practice steps involved in the innovative process.

Assessment Plan

Lesson 1

Formative Assessments

- Teacher observation of partners discussing answers to questions about a chosen innovation and then sharing them with the class. Teacher is looking for understanding of innovations, evaluation as to the value of the innovation, the pros and cons to the innovations and reasons to back up the chosen position. Teacher is also looking for understanding of how purpose influences innovation.
- Teacher observation of the Socratic Seminar. Looking for connections and understanding of relevance from the reading to purpose, innovation, resources, and value of failed innovation attempts. Teacher is also observing for student strengths and struggles in social situations and leadership roles for future application.
- Students complete an observation on their partner during the Socratic Seminar. Teacher can use this as evidence to support or question their own impressions of student strengths and struggles.
- Students will answer in writing reflective questions about the seminar and four questions about innovation. This information will be used by the teacher to assess overall understanding of the concept of innovation.

Lesson 2

Formative Assessments

- Student teams keep record on the purchase order and financial record. These will be evaluated for accurateness and understanding as the students meet with the teacher to make purchases.
- Teacher circulates to observe teams as they discuss and plan their course with the purpose of observing higher-level thinking skills in problem solving and design.
- When build is complete hole will be tested by creators, other teams, teachers, and outside judges to make sure that all requirements are met and the purpose is fulfilled.
- A final report of each team's budget and expenses will be assessed after class.
- Teacher listens as teams to share the thought behind their design through answering questions about the process. This gives these gifted learners the opportunity to self-evaluate.
- Each student will write a short reflection (on large note cards) about how the purpose of the mini-golf course influence the innovation they used in their design. The reflection will be posted with the holes for the judges' consideration.

Lesson 3

Formative Assessments

- Teacher evaluates student understanding during whole and small group discussion throughout lesson. Discussion is guided by teacher questions, as well as student input. Check for understanding and depth of knowledge in key concepts and new content.
- Students groups build bridges that must hold at least 4lbs for one minute. They will also share the answers to the questions in the Evaluate section of the plan. Through observing their bridge when weight is added to it and hearing their answers to the questions, teacher will get a good sense of student understanding of the concept of building, and their ability to apply math and science content and principles to the design of the bridge.
- Students then evaluate themselves and their teammates using the following rubric and questions.

CREATIVE-COLLABORATIVE TASK RUBRIC

My Name _____

Circle One: Self-Assessment Peer Assessment Teacher Assessment

Assessment of _____

Date _____

Score /28

CATEGORY	4	3	2	1
Creativity X2	Routinely shares unique, insightful, or useful ideas with the group	Shares ideas that improve upon other's ideas (piggy-backing) or is able to creatively combine multiple ideas	Ideas shared with group are typical or show little original thinking	Does not contribute ideas to the group.
Problem-Solving X2	Actively suggest high-level solutions to problems. Use of innovation, synthesis, or evaluation is evident.	Actively suggest solutions to problems. Use of appropriate problem solving process including analysis and application is evident.	Attempts problem solving, but is incomplete in application. Demonstrates trouble with logical steps.	Does not try to solve problems.
Listening, Questioning, and Discussing	Respectfully listens, interacts, discusses and helps direct the group in reaching consensus.	Respectfully listens, interacts, discusses and poses questions to others during discussions.	Has some difficulty respectfully listening and discussing, and/or tends to dominate discussions.	Does not listen to others, argues with group, and is unwilling to consider other opinions.
Focus on the Task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Must be reminded to keep on task.	Rarely focuses on the task and what needs to be done. Allows others to do the work.
Group Participation and Teamwork	A strong team member who contributes a lot of effort while encouraging and supporting the efforts of others in the group.	A strong group member who continually puts for the effort.	A satisfactory group member who does what is required most of the time.	A weak team member who sometimes chooses not to participate or complete assigned tasks.

Rubric adapted from: Kingore, B. (1998). Engaging Creative Thinking, (pp. 39). Austin, TX: Professional Associates Publishing.

What was your favorite thing about this challenge?

What would you change about this challenge?

What was the most memorable lesson you learned from this challenge?

How do you think purpose influences innovation?

Lesson 4

Formative Assessments

- Teacher evaluates student process skills through whole and small group discussions focused on pictures of innovations.
- Students write captions to enhance the understanding of pictures in collaborative groups, and then independently.
- Throughout these the teacher will be looking for the following process skills...
 - Analyze images to create understanding
 - Interpret details and expression to infer meaning
 - Collaborate with various groups to build on others' ideas
 - Construct viable arguments and critique the reasoning of others
 - Empathize with subjects in pictures
 - Speculate circumstances that lead to capturing a picture
 - Apply understanding of innovation and how purpose influences innovation to understanding of pictures
 - Problem solve through observation, clue-finding, and drawing conclusions

Performance Task

Summative Assessment

World Expo Innovation Competition

Calling all Young Innovators! Bright Minds Foundation is looking for creative, innovative, engineering designs by students to be showcased at the next World Expo. They will be traveling across the country giving students the opportunity to compete for the chance to represent the United States. To prepare for this experience, young innovators will design, build, and present their most promising and purposeful innovation.

The presented innovation should go along with the World Expo theme, "Connecting Minds, Creating the Future". The presentation should have three parts: a demonstration of a working model, a thorough description of all design parts including their function, and a "sales pitch" highlighting the value of your design. The value of your design should include the purpose of the design, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future. Distinguished

Resources

World's Fairs. (2015). Calendar of Events. Retrieved 06/02, 2016, from <http://worldsfairs.com/calendar-links/>

World Expo Innovation Competition

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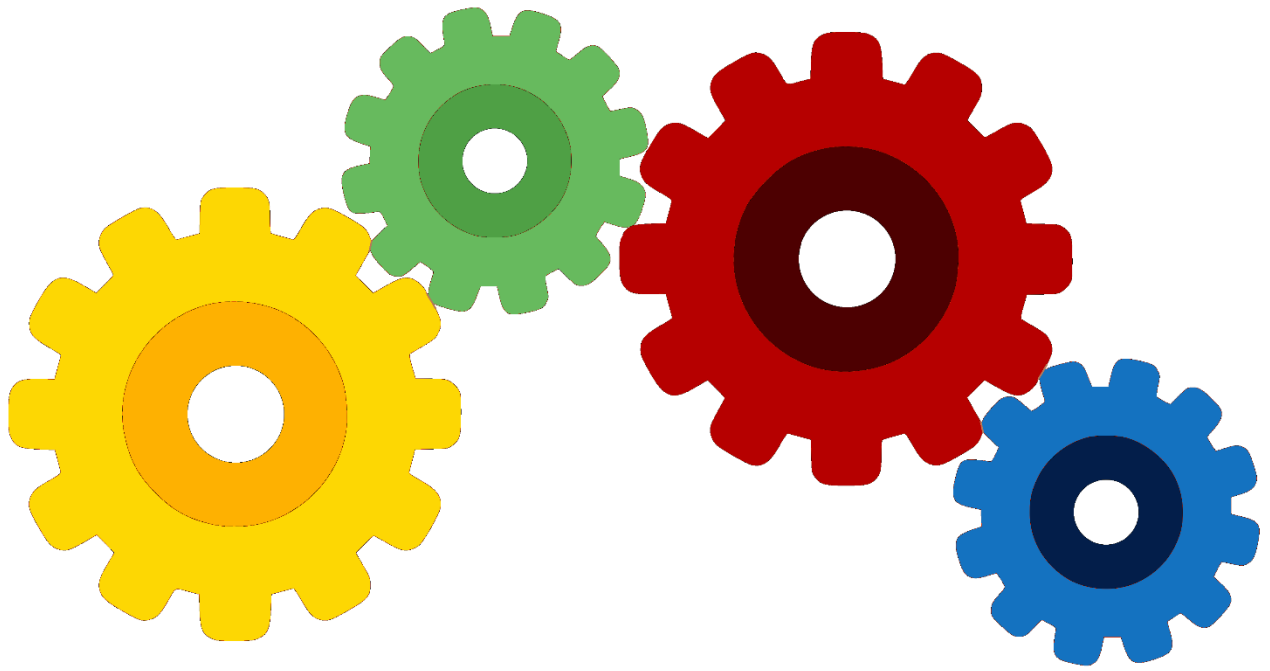
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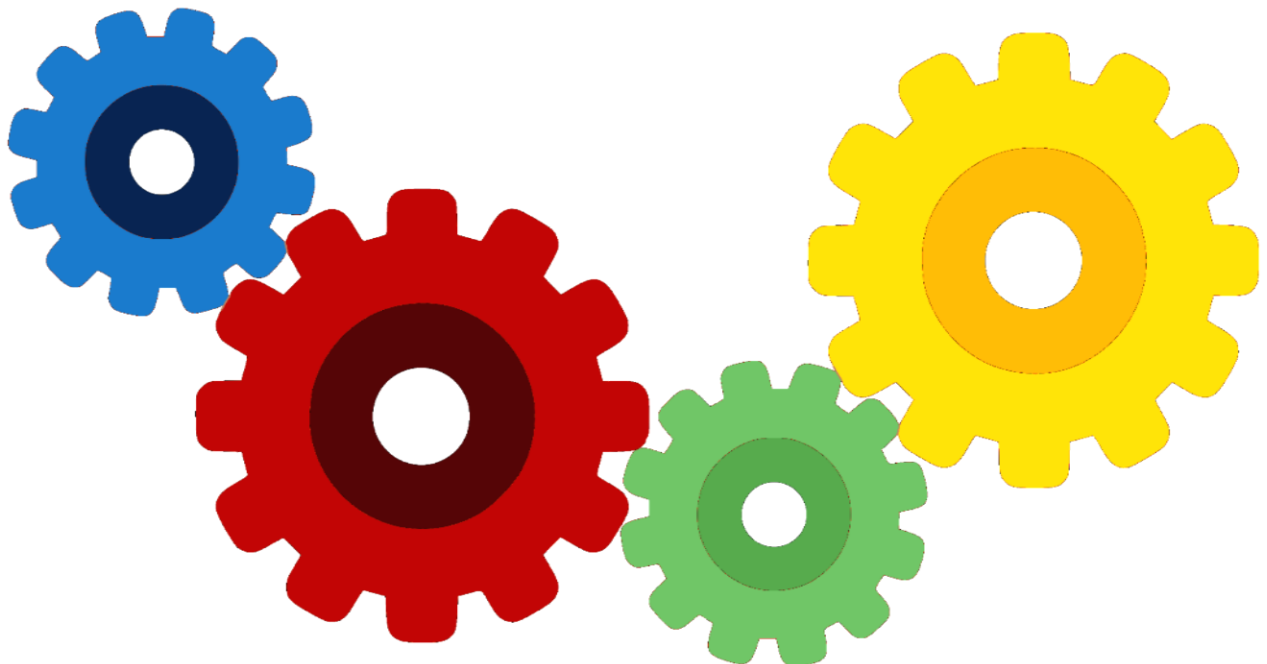
WORLD EXPO INNOVATION COMPETITION - PERFORMANCE TASK RUBRIC

Student Name _____ Date _____

CATEGORY	1	2	3	Score
Evaluation of Process X2	A developing use of processing skills such as critical thinking, inferencing, evaluating, and collaborating is evident through a partial or incomplete description of design parts and their function	An average use of processing skills such as critical thinking, inferencing, evaluating, and collaborating is evident through a substantial description of all design parts and their function	An accomplished use of processing skills such as critical thinking, inferencing, evaluating, and collaborating is evident through a thorough and complete description of all design parts and their function	
Understanding of Concept X2	A not yet competent understanding of innovation is evident in a presentation that is ineffective in communicating the value of the design by including less than 3 out of the following four points... its purpose, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future	A competent understanding of innovation is evident in a presentation that is somewhat effective in communicating the value of the design by including 3 out of the following 4 points... its purpose, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future	A sophisticated understanding of innovation is evident in a presentation that is highly effective in communicating the value of the design by including... its purpose, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future	
Depth of Content Knowledge	A novice application of content skills is evident in an inoperable model of the innovation	A competent application of content skills is evident in a partially operational model of the innovation	An advanced application of content skills is evident in an operational model of the innovation	
Evaluation of Product	An unacceptable innovation is presented and/or the innovation was not relevant to the theme, “Connecting Minds, Creating the Future”	A proficient innovation is presented and/or the innovation was marginally relevant to the theme, “Connecting Minds, Creating the Future”	An exemplary innovation is presented that is clearly relevant to the theme, “Connecting Minds, Creating the Future”	
Total				



Lesson Plans



TEACHER NAME		Lesson #
Laura Pryor		1 (Day 1)
MODEL	CONTENT AREA	GRADE LEVEL
Socratic Seminar	ELA/Science	4 th /5 th
CONCEPTUAL LENS		LESSON TOPIC
Innovation		Innovation in Engineering
LEARNING OBJECTIVES (from State/Local Curriculum)		
ELA <i>Integration of Knowledge and Ideas K-5</i> 7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words. 8. Delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence. <i>Reading Standards for Informational Text</i> 4.3. Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. 5.1. Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. 5.3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)
Purpose influences innovation		How does purpose influence innovation?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know... - How purpose influences innovation - How problems create purpose - Valuable steps involved in the innovative process - Innovation can be achieved by all people - There is value in unsuccessful attempts at innovation - That innovation and engineering do not always coincide		Students will be able to ... - Develop open ended higher level thinking questions - Analyze content and discussion while making connections - Infer cause and effect - Draw conclusions - Compare ideas - Synthesize information from multiple sources - Construct viable position statements and give evidence to support these statements - Disagree with positions and reasoning of others in a positive, productive manner - Explain how purpose influences innovation - Distinguish the influence that purpose has on particular innovations - Create a new idea for innovation - Predict possible hindrances with innovations - Judge value of innovation
GUIDING QUESTIONS What questions will be asked to support instruction? Include both “lesson plan level” questions as well as questions designed to guide students to the essential understanding		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
What did you observe in this clip? How could the boy have been more persuasive in selling his idea? How would you justify the entrance of the backpack into the exhibition? How would you justify keeping the backpack out of the exhibition? What value can you find in this invention? What purpose did the boy have in designing the backpack? What does engineering involve? What makes it different from other forms designing? How would you define “innovation”? How are engineering and innovation related? When can engineering be called, “innovative”? When can it not be seen as innovative? How are purpose and innovation related? Who can be an innovator?	What problem did this innovator recognize? How is the problem related to the innovator’s purpose? How do you believe the problem influenced the innovation? What would make this creation qualify as an innovation? What recommendations could you make to improve this innovation? If this product was produced and available for the public, how successful do you predict it would be? What problems do you foresee could hinder the usefulness of the innovation? What makes this ball any different from the others? How does this difference give the boys purpose? How does purpose influence the innovation by the boys?	What is the most interesting thing your partner said? What would you like to have said in the discussion? What is innovation? What is the most important thing that you believe can be learned through failed innovative attempts? How does purpose influence innovation? What steps should be used when innovating?

	What do you believe was the primary purpose/motive driving the boys' innovation? How are purpose and resources related? What do you predict would be the long term consequence of not getting the ball back? What patterns were used when the boys attempted new innovations?	
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DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.)

Content	Process	Product	Learning Environment
	Participation in this Socratic Seminar will require students to formulate questions that can be discussed at a high level of understanding. The seminar will also be student led.	The student answers and insight will vary according to the various abilities of each student. Gifted learners can incorporate what they know as well as in-depth questioning into the conversation and their written answers.	Students will work in various forms of grouping including Socratic Seminar with the whole class, small group, and independent work. The variety of environments will give students opportunity to go as deep in understanding as they are able.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students. **(10-15 minutes)**

Hook students by showing them a clip from the movie *Tomorrowland*.

<https://www.youtube.com/watch?v=JRM8EU04U&list=PLzGG1mSveHbXBiggWacn7Jl5y7QcCRAd8>

What did you observe in this clip?

How could the boy have been more persuasive in selling his idea?

How would you justify the entrance of the backpack into the exhibition?

How would you justify keeping the backpack out of the exhibition?

What value can you find in this invention?

What purpose did the boy have in designing the backpack?

Though this is a fiction clip from a movie, it is based on a true piece of history. The World Fair really was in New York in 1964. Show slides 4-6 in PowerPoint.

Then draw out students' prior knowledge and get them thinking about what we will be learning about with the following questions discussed as a class:

What does engineering involve? (Make sure that the connection between using math and science to create something is touched upon.) What makes it different from other forms designing? How would you define "innovation"? How are engineering and innovation related? Can all engineering be defined as innovation? How are purpose and innovation related? Who can be an innovator?

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Now that students have a general idea of what is involved in innovation, show students slides 7-9. **(5-10 minutes)**

Discuss the slide and video as a class using the following questions (slide 10):

1. What problem did this innovator recognize?
2. How is the problem related to the innovator's purpose?
3. How do you believe the problem influenced the innovation?
4. When can engineering be called, "innovative"?
5. When can it not be seen as innovative?
6. What recommendations could you make to improve this innovation?
7. If this product was produced and available for the public, how successful do you predict it would be?
8. What problems do you foresee could hinder the usefulness of the innovation?

Now show the next three innovations (slides 11-16) Afterward partners will pick one of the innovations to discuss and answer the questions above (slide 17) on your paper. Teacher will circulate among groups during this time. **(10 minutes)**

Once complete, groups have the opportunity to share answers with the class. **(5 minutes)**

Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

Introduce our article through showing students a clip from *The Sandlot* 1:00:24-1:02:11 Give a brief overview of the overall situation prior to showing the clip. Emphasize that once a ball goes over the fence it is gone for good. The "Beast" is rumored to be deadly and that no living being has returned from its domain. After the clip ask what problem the boys have. What makes this ball any different from the others? How does this difference give the boys purpose? **(15 minutes)**

Now hand out a copy of "Learning about innovation from a bunch of kids" (attached) and listen as the teacher reads the article aloud. Students should follow along listening to the words as they are being read.

Then students should read through the article, “Learning about innovation from a bunch of kids” independently using the “closed reading” process. On overhead (slide 18) show a shortened list from “Socratic Seminar Guidelines” p. 5 (see below) and discuss how to be prepared to discuss the article. Emphasize that students should each prepare three open ended questions that could have multiple answers. These may be used as discussion question during the Socratic Seminar. **(15-20 minutes)**

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

Once students have completed the closed reading and questions are completed, students are all divided in half by having one person from each pair going to each side of the room. Then one side of the room circles up to become the inner circle. The group on the other side of the room circles up around the inner circle to become the outer circle. Each person in the outer circle should sit where they can see their partner in the inner circle. Students will all be given a Socratic Seminar Observation Form. As a class we will all review on the overhead (slide 19) the Socratic Seminar Guidelines (from Socratic Seminar Student Handout, p. 5) that we will abide by during the Socratic Seminar. **(5 minutes)**

The Socratic Seminar will begin with a student leader facilitating the discussion and starting out with a question from his or her list of three questions. As the discussion takes place in the inner circle, the outer circle will each observe his or her partner and record observation on the Observation form.

Possible questions for opening or continuing of dialogue:

How does purpose influence the innovation by the boys?

What do you believe was the primary purpose/motive driving the boys’ innovation?

How are purpose and resources related?

What do you predict would be the long term consequence of not getting the ball back?

What patterns were used when the boys attempted new innovations?

In approximately 10 minutes the dialogue will be paused while the inner and outer circles will switch roles. Then the dialogue will resume with the inner circle participating and the outer circle observing and recording. **(25 minutes)**

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

When Socratic Seminar comes to a close, students will spend a few minutes answering the “After” questions on the bottom of their Observation Form to aid in reflection on what was said during the Seminar. **(5 minutes)**

As a final evaluative tool students will answer the following questions on the back of their Observation Form. (Slide 20)

What is innovation?

What is the most important thing that you believe can be learned through failed innovative attempts?

How does purpose influence innovation?

What sparks innovation?

As a class, debrief the lesson through whole class discussion using the student answers to those questions. **(5 minutes)**

Students will turn in their answers to be used as formative assessment of student understanding.

After Socratic Seminar lesson, performance task will be introduced using slide 21. Point out that this week students will have the opportunity to use their innovation and engineering skills in various projects, but that the finale will be this performance task. It is being introduced now so that students can plan and have time to gather needed supplies. The majority of their work will be done on Friday. **(5-10 minutes)**

Today, give students time to form partnerships, brainstorm ideas, and research topics that could be used for their performance task. Students may work cooperatively in partners or as individuals if they prefer. **(15-20 minutes)**

Learning about innovation from a bunch of kids

By: InnovationTools.com

In: [Innovation Strategy](#), [Innovation Weblog](#)

1 **Sometimes the approaches used by kids to solve problems can provide a good model for all of us to follow.**

2 This week my young niece and nephew are visiting us for a few days. As usual, entertaining them is a challenge, and
3 movies are usually a good diversion. Having already seen most of my collection of kids movies, we decided on one of my
4 all time favorites – *The Sandlot*.

5 I won't go into the details of the plot line, but as I watched the movie it dawned on me that there is quite a story of
6 innovation subtly hidden amongst the many antics of the pre-teen characters. In short, the story is about a bunch of rag-tag
7 kids who have to retrieve a baseball from the yard next to the sandlot where they play. Not just any baseball though, but
8 one signed by none other than the "Great Bambino."

9 Near the middle of the movie there are several scenes where the kids come up with creative ways to retrieve the ball,
10 which is guarded by a dog appropriately named "the beast." As I watched the movie, I realized there were several lessons
11 to be learned from their trials and tribulations.

12 **Understand and agree upon the driver(s) of your innovation.** In their case, it was fear that took on several forms. Fear
13 of "the beast." Fear of retribution. Fear of failure. They clearly understood what was driving their strategies for creating
14 solutions to their problem. This is a key element in building an innovation strategy. Simply innovating with the hope of
15 creating something or doing something worthwhile has a very low probability of success.

16 In today's market where competition is fierce, resources are scarce and chances for survival are tougher than ever, it's
17 essential to invest your resources as wisely as possible. You must be able to rationalize, agree upon, and communicate
18 your strategy.

19 **Use the resources you have at hand.** The setting for the movie was the 1960s, a time when baseballs cost 98 cents. For
20 this bunch of kids, that was a huge amount of money. So creating solutions to their problem required the creative use of
21 items at their disposal – vacuum cleaners, erector sets, ropes and pulleys. Innovation does not require huge
22 investments. Granted, it can be accelerated by having the latest and greatest tools at your disposal, but creating new
23 capabilities or solutions to problems can be realized through the use of existing corporate assets. The key is discovering
24 them and then using them in creative and innovative ways – feeding the cycle of innovation.

25 **Innovate rapidly.** In the movie, the kids were under tremendous pressure to retrieve the ball before its owner (one of the
26 dads) returns from a business trip. This led to the rapid development of different "ball retrieval" solutions in a very short
27 time frame. Product development cycles that are shorter than ever, combined with intense market pressures, requires that
28 we continue to innovate at a pace heretofore unseen.

The good news is that we can learn from the work of others. No longer are we in isolation (unless we choose to be) when we are working on ideas. We have a wealth of information at our fingertips. Learn from your mistakes and move on – don't dwell on them.

Know when to change direction. After a few failed attempts at retrieving the ball, one of the kids makes a suggestion that they have been going about it all wrong. Thus a new strategy is born. One of the traps of innovation is sticking with an approach in the hopes that the answer will be found, or just another ounce or two of improvement can be squeezed out, or maybe just a little more competitive advantage can be realized. We should all heed the popular definition of insanity – doing the same thing over and over with the hope that the outcome will be different. Don't waste valuable, scarce resources on minor incremental improvements.

Know when to quit innovating. Unfortunately for the kids, all their great ideas came to the same conclusion – the baseball was still in possession of “the beast.” At some point we all have to make that tough decision to call it quits and declare failure. It's a tough thing to do, especially when you have invested significant corporate (or your own) resources in the process. But EVERY innovation cycle should be viewed as a victory. Innovation is about learning. And learning is valuable.

Play to your strengths. One of the kids, Benny “The Jet” Rodriguez, is known for his blazing speed. In the end, he's the solution the ball retrieval problem. Just like knowing when to quit innovating, going back to and leveraging your core strengths can be a tough decision. Innovation is fun. But at some point you need to be able to step back and make the determination that what you may already have is pretty good. Realizing that value can be tough sometimes – especially when you are caught up in the day-to-day issues of creating shareholder value. But coming to that realization in and of itself is part of the innovation process.

Sometimes the simplest answer is the best. James Earl Jones plays the owner (Mr. Mertle) of the house next to the sandlot -where “the beast” lives. Near the end of the movie the kids finally get up the courage to talk to him about what has happened. To their surprise he asks them a very simple question: “Why didn't you just knock on the door?”

Sometimes stepping back and asking very simple questions may lead you to a different strategy. Do you really need to invest in innovation for this problem or opportunity? Could our scarce resources be better spent solving another problem? Is there a simpler way to find the answer we are seeking? Will this investment give us the best ROI? Questions may lead you to a better investment strategy for your innovation dollars!

These are simple examples from somewhat of a unique source for innovation inspiration. But I think if you look at them (and maybe watch the movie) you will see that real-world solutions often provide some of the best guidance when embarking on a path of creating something new or solving a tough problem.

Happy innovating!

Socratic Seminar Guidelines

Revised student handout from “Socratic Seminar Guidelines” p. 5.

Make notes while you read the article so you are prepared for a quality discussion of the text:

Mark the text by:

- ❖ Circle terms that are important to understanding your text – if there are terms you do not understand add a question mark
- ❖ Underline ideas that are important
- ❖ Record your thoughts in the margin of your text
- ❖ Record questions that come to your mind as you are reading in the margin of the text

Prepare for discussion by creating three questions that would promote discussion.

Questions should:

- ❖ Have no one correct answer
- ❖ Require explanation to answer
- ❖ Be higher level questions

Suggestion for questions:

- ❖ Ask about viewpoint of the writer or others
- ❖ Ask questions that allow interpretation of the reading- yours and your classmates’
- ❖ Ask about meaning
- ❖ Ask about importance

Resources

- Brainjet: Daily Cerebral Stream. (2016), 12 technologies people thought were mind blowing at the 1964 world's fair. Retrieved 6/11, 2016, from <http://www.brainjet.com/random/3836/12-technologies-people-thought-were-mindblowing-at-the-1964-worlds-fair#page=4>
- InnovationManagement.se. (2016). Learning about innovation from a bunch of kids. Retrieved 6/11, 2016, from <http://www.innovationmanagement.se/imtool-articles/learning-about-innovation-from-a-bunch-of-kids/>
- Makosinski, A.(2014). Can I power a flashlight without batteries? Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=yrrNmzSSn0w>
- Singh, K. (2014). 9 incredible science projects by brilliant kids. Retrieved 6/11, 2016 from <http://mashable.com/2014/08/26/science-projects-kids/#tzTE9.UXqGqx>
- Taylor, A. (2014). 1964: the new york world's fair. Retrieved 6/11, 2016, from <http://www.theatlantic.com/photo/2014/06/1964-the-new-york-worlds-fair/100749/>
- YouTube. (2013). 2013 young scientist challenge winner: Peyton Robertson. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=TWTEceGEyYU>
- YouTube. (2014). Hot Car Safety System. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=jx4E5CHL50E>
- Youtube. (2014). iGlasses HD. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=nSJ8BN5SSHY>
- YouTube/E3. (2015). Tomorrowland (1/10) movie clip - welcome to tomorrowland (2015) HD. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=JRmR8EUpo4U&list=PLzGG1mSyehbXBigqWacn7JI5y7QcCRAd8>

TEACHER NAME		Lesson #
Laura Pryor		2 (Days 1 & 2)
MODEL	CONTENT AREA	GRADE LEVEL
Simulation	Social Studies/Math	4 th
CONCEPTUAL LENS		LESSON TOPIC
Innovation		Market Economy
LEARNING OBJECTIVES (from State/Local Curriculum)		
Social Studies 4.E.1.1 Understand the basic concepts of a market economy: price, supply, demand, scarcity, productivity and entrepreneurship. 4.E.1.2 Understand how scarcity and choice in a market economy impact business decisions. 4.E.2.2 Explain how scarcity of personal financial resources affects the choices people make based on their wants and needs.		
Math 7.RP.3 Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)
Purpose influences innovation		How does purpose influence innovation?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know... • That an engineer must respond to available resources by using innovation • That supply, demand, scarcity, and productivity affect price • Purpose influences planning and design of innovation • Resources affect choices and business decisions • The steps needed to solve multistep percent problems • That science and math concepts are useful and necessary in designing and building.		Students will be able to ... • Successfully respond to changes in resources while fulfilling purpose by exhibiting innovation, flexibility, and stamina in problem-solving • Apply proportional relationships to solve multistep percent problems • Apply concepts from science and math during design and construction • Analyze problems and persevere in solving them • Construct viable arguments & critique the reasoning of others • Reason abstractly and quantitatively • Utilize appropriate tools strategically
GUIDING QUESTIONS What questions will be asked to support instruction? Include both “lesson plan level” questions as well as questions designed to guide students to the essential understanding		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
How would you describe your experience and opinion of the hole Who if anyone would enjoy that type of mini-golf course? What adaptations could be made to improve the experience for the golfer? How would you define innovation? What drives innovation? What did students in this news clip do? What are the parts of the mini- golf course? What was the purpose for constructing the golf course? What are resources? What resources did these students have? How do you think the resources that the students had available shaped their innovation? How were the resources related to the purpose of the innovation? How does this challenge and the changes in circumstance, relate to the “real-world”? What challenges could be presented to the players? What are possible ways to make sure that all build requirements are met? What materials are affordable with the monetary resources that we have available? What hazards can be engineered to cause a change in the ball’s direction while in motion? What will cause a change in the ball’s elevation on its way to the hole? How does this plan work for our purpose?	How can we determine the mark-up or mark-down of the price? How do we determine how this event will change our budget? How is our budget related to our purpose? How do you believe you would feel if your team’s budget is reduced? What does percent mean? How can we represent percent using decimals and fractions? How many steps are needed to solve this problem? What supplies can we afford with our current budget? Is there another option that would be more cost effective? What financial resources should we keep on reserve for situations that may arise during our build? What supplies are most important to purchase? What supplies should be purchased first? If you can no longer afford needed supplies, what adaptations can you make to your plan? What substitutions can be made for building supplies? How can you apply your innovation skills to make needed changes? What additional components, if any, do we need to begin the build? How would beginning the build at this point without all needed components compromise the integrity if the build?	What innovations did you come up with to fulfill the requirements of the hole? Why did you choose the original supplies on your purchase request list? What challenges did you face in the building process? How did you feel when the Turn of Event cards did or didn’t make a difference for your team? What difference did the Turn of Event cards make in your resources? How did your resources influence the supplies you were able to purchase? In what ways did your resources shape your innovation? What forces influence the ball directions on your hole? After playing all holes, in what ways do you think other teams’ resources shaped their innovation? What build designs did you find particularly resourceful and why? How do you think resources influence innovation? How does purpose influence innovation? How did the purpose influence your design?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.)

Content	Process	Product	Learning Environment
Concepts are introduced and explored that are advanced for this age group. (from 7 th grade curriculum) - Solving percent problems	Participation in this simulation will require an advanced level of understanding of concepts in order to make necessary adjustments to continue to build with available resources.	The student products will vary according to the various abilities of those in each group. This is beneficial for allowing gifted learners to incorporate what they know into the product while allowing them to grow through exploration and innovation.	Students will be clustered with other gifted learners. They will work in student lead collaborative groups.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.

As students enter the classroom, they will have the opportunity to take a turn hitting a golf ball into a simple hole set up. (If we are able to start this on Day 1, students will do this taking turns while others are working on their performance task.) Once all students have had a turn ask: How would you describe your experience and opinion of the hole? Expected responses would be that it is simple, easy, or boring. Who if anyone would enjoy that type of mini-golf course? What adaptations could be made to improve the experience for the golfer? **(10 minutes)**

After our lesson yesterday, how would you define innovation? What drives innovation? Watch this video to get an idea of what our challenge today involves.

<http://www.bigcountryhomepage.com/news/ktab-news/students-create-cardboard-mini-golf-course-for-charity>

What did students in this news clip do? What are the parts of the mini- golf course? (If students do not mention the tee, green, or hole, make sure to bring them up and discuss those terms.) What was the purpose for constructing the golf course? Make sure students understand that the purpose was to raise money for charity without spending money for supplies. What are resources? What resources did these students have? How do you think the resources that the students had available shaped their innovation? How were the resources related to the purpose of the innovation? **(5-10 minutes)**

Today, your challenge will involve innovation using a variety of resources. The key is that in this challenge, you will find that circumstances change and affect your resources. Your purpose will stay the same and will include utilizing available resources. This is what happens continually in life. How does this challenge and the changes in circumstance, relate to the "real-world"?

Your engineering firm is vying for a contract to build a new mini-golf course here in Durham. This contract is a big deal, because it could lead to a contract for a chain of new mini-golf courses that will be built throughout the country. Several firms have proved that they would do a fantastic job designing the course, so to help decide who will be awarded the contract, the company has set up a competition. Each engineering firm has put together a team of their best designers and you have been chosen as a member. It is up to your team to play by the rules of the contest and create an innovative design that will sway the company executives so they will pick your firm for the contract. The purpose of the new mini-golf course will be to attract customers from the surrounding area as well as tourist. It will be marketed as family friendly business with a course that is exciting and challenging for all ages. Keep this purpose in mind as you strive to create the most innovative and exciting hole possible.

Students will be randomly given a sticker and will find two other people with the same sticker to determine teams.

Before the challenge is given, find your team members (3 on each team) and write your engineering firm name (students create the name) on the designated name plate to be displayed by your finished product as well as a smaller card to represent your firm on the "Turn of Events" chart on the board. **(10-15 minutes)**

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

The challenge is given (and passed out for review) **(5 minutes): Teams are challenged to design and build one section (hole) of a mini- golf course on a budget. Each team will start with the same amount of (play) money that has been supplied by their firm. Teams must purchase necessary supplies for their build with this budget, but will encounter various factors that will influence available resources. The end result should be a mini-golf experience that is enjoyable for the golfers of all ages and would attract family business.**

Build Requirements

1. The section for each hole (entire area of play) must be less between 8 and 12 square feet and should be taped off using painters tape.
2. Ball must travel a change of elevation (go up or down) in order to reach the hole.
3. Ball must change direction through turns or bends in the course as it travels to reach the hole.
4. Barriers should be constructed to keep the ball from traveling out of the designated green for the hole.
5. The hole must be designed so the ball will stop and not fall, roll, or bounce out.
6. Only materials on the available supplies list may be used. (included list is a guess as available supplies may vary depending upon resources I can collect)
7. Supplies must all be purchase with team funds at the current price, unless a "Turn of Event" card denotes otherwise.
8. An accurate record of team funds, purchases, and supplies must be kept.

Team Guidelines:

1. Students work in groups of 2-3 people.
2. Groups must work cooperatively and respectfully
3. One team member should be responsible for recording on the purchase order and conducting purchases.
4. All team members are responsible for accurate calculations and participating in all aspects of the planning and build.
5. Materials may not be shared among groups
6. Students should only touch their own team's build and materials
7. Each group must clean up their work area.
8. Creativity and attention to purpose is encouraged. Be innovative in designs.

Every team will receive: 1 roll of masking tape, 1 yard stick, 1 golf ball, 1 golf club, 3 pairs of scissors, access to painters tape for marking off the team's area of play

The teams will follow the following schedule of events, but after the first 15 minutes, the students will be interrupted for a turn of events every 7 to 10 minutes. **(total simulation and built time should be no more than 120 minutes)** During the turn of event, a representative from each team will roll a die and record the number on the Turn of Events Chart on the board. One card will be drawn from the Turn of Event cards and posted with the corresponding event. **(Note: Turn of event cards are printed with blanks for the name of the supply, price, and percent changes so they can be laminated and used repeatedly. Supplies, prices, and percent changes may change according to resources available when the simulation occurs.)** The Turn of Event card will be applicable to teams that rolled either even or odd numbers, depending upon the notation on the Turn of Events Card. The card will be posted on the chart in the row for that event and all affected teams, must make needed changes on their Purchasing Record. All prices and budgets will be affected from that point on in the project unless otherwise noted.

Schedule

1. As a team, brainstorm by sharing ideas of what your section could look like. What challenges could be presented to the players? What are possible ways to make sure that all build requirements are met? What materials are affordable with the monetary resources that we have available? Make various sketches as needed to share your ideas.
2. Design a plan that incorporates your best ideas and meets the requirements. See teacher for painters tape to mark off your 8-12 sq. ft. for your hole with painter's tape. Consider: What hazards can be engineered to cause a change in the ball's direction while in motion? What will cause a change in the ball's elevation on its way to the hole? How does this plan work for our purpose?

Explain - *Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.*

(During the following steps, Turn of Event cards will be pulled for the first time. Students will need to know how to mark up and down prices as well as their budget. When the first card is drawn, as a class, work out how to find out the change in price or the change in budget. When the 2nd turn of events occurs, have all teams solve the problem regardless of whether or not they are affected. Check to make sure that each team has solved the problem correctly. As the simulation continues, give support with new math concepts as needed. Questions used during this instruction: How can we determine the mark-up or mark-down of the price? How do we determine how this event will change our budget? How is our budget related to our purpose? How do you believe you would feel if your team's budget is reduced? What does percent mean? How can we represent percent using decimals and fractions? How many steps are needed to solve this problem?)

3. Come up with a financial plan. What supplies can we afford with our current budget? Make sure to take into account the current cost and the number of each supply needed. Is there another option that would be more cost effective? What financial resources should we keep on reserve for situations that may arise during our build?
4. Make purchases when your team is called by the Supply Master. Each team will have the opportunity to purchase one type of supply at a time. Determine: What supplies are most important to purchase? What supplies should be purchased first?

Elaborate —*Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways*

5. Every time an event occurs, make adjustments to prices or budget. Adjust plans and purchases depending upon the resources you have available as well as changes in cost. Continue to make purchases when allowed until all needed supplies are acquired. Have we adjusted prices and our budget as necessary on our Financial Record? If you can no longer afford needed supplies, what adaptations can you make to your plan? What substitutions can be made for building supplies? How can you apply your innovation skills to make needed changes?
6. Once your team has enough supplies purchased, you can begin your build and add on as supplies are purchased. What additional components, if any, do we need to begin the build? How would beginning the build at this point without all needed components compromise the integrity of the build?
7. When build is complete test your hole. Make sure that all requirements are met and your purpose is fulfilled.
8. Put together a final report of your team's budget and expenses.
9. Each team member should play through the hole and record the scores.
10. As a team, determine what par for the hole will be. Par should not be lower than the lowest score any team member scored. What would be a fair par for this hole?
11. Post a sign with your firm name showing what Par for your hole is.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

12. Once all par signs are posted, allow all teams to play all holes. **(20 minutes)**
13. As a whole class, debrief the activity. Allow all teams to share the thought behind their design through answering the questions below. **(10 minutes)**
 - What innovations did you come up with to fulfill the requirements of the hole?
 - Why did you choose the original supplies on your purchase request list?
 - What challenges did you face in the building process?
 - How did you feel when the Turn of Event cards did or didn't make a difference for your team?
 - What difference did the Turn of Event cards make in your resources?
 - How did your resources influence the supplies you were able to purchase?
 - In what ways did your resources shape your innovation?
 - What forces influence the ball directions on your hole?
 - After playing all holes, in what ways do you think other teams' resources shaped their innovation?
 - What build designs did you find particularly resourceful and why?
 - How do you think resources influence innovation?
 - How does purpose influence innovation?
 - How did the purpose influence your design?
14. Turn in your financial report.
15. Each student should write a short reflection **(on large note cards)** about how the purpose of the mini-golf course influence the innovation they used in their design. All paragraphs should be posted with the par signs for consideration during evaluation by company executives. **(10 minutes)**
16. After teams have left for the day, the company executives (i.e. unbiased adults/teachers/children not in the class) will play and evaluate each engineering firm's work. All financial reports will be evaluated for accurate record keeping and innovative use of resources. A decision will be made about which firm will be awarded the contract based upon innovative design that translates to an enjoyable experience and fulfills the purpose of the challenge. Teams will be notified of the judges' decisions the next day.

Odd	A newer model of _____ has come out so you can get the current model for a _____% decrease.	Even	Best Bargains is going out of business. In hopes of liquidating their stock, they have cut prices on all _____ by _____%.
Odd	A newer model of _____ has come out so you can no longer get the current model. You will have to buy the newer model for _____% more.	Even	A warehouse fire has recently caused a huge shortage in _____ causing a shortage in supply. The cost has been raised by _____%.
Odd	One store chained has a huge sale in hopes of attracting shoppers on a particular weekend. They offer deep savings on a few items that will draw shoppers to their store. Luckily, one of the great bargains is 50 % off _____. (Lasts until the next event)	Even	The grandfather of one of your team members was cleaning out his shop and found 5 _____ that he was willing to donate to your build.

Odd	One of your team's cutting machines stopped working. Since it was borrowed, you will have to pay to have it repaired. The cost takes _____ % of your budget.	Even	Your team had a freak accident during their build. Thankfully, no one was injured. Unfortunately, all of your _____ were ruined and can no longer be used in your build. You will have to buy new _____ if you still want to use them in your build.
Odd	Your team lucked out and found 30 _____ for sale at a second hand shop. You are able to buy 30 for _____% less than the regular price.	Even	Your team just found out that they will won a Bright Ideas grant for its innovative engineering design in a recent contest. Using a portion of the grant, you are able to increase your current budget by _____%.
Odd	The company that sells _____ has recently spent millions of dollars on a marketing campaign. Due to the recent expenses they have incurred for advertising, they have slightly raised their prices by _____% in hopes of making more money in what they hope will turn into a higher demand for their product.	Even	Your engineering firm just found out that it is going to have to pay a large unexpected tax. Unfortunately that means they have to cut your budget by _____% to make ends meet.

Financial Record - p. 1

[illegible]

Financial Record - p. 1

[illegible]

Performance Task

Calling all Young Innovators! Bright Minds Foundation is looking for creative, innovative, engineering designs by students to be showcased at the next World Expo. They will be traveling across the country giving students the opportunity to compete for the chance to represent the United States. To prepare for this experience, young innovators will design, build, and present their most promising and purposeful innovation.

The presented innovation should go along with the World Expo theme, “Connecting Minds, Creating the Future”. The presentation should have three parts: a demonstration of a working model, a thorough description of all design parts including their function, and a “sales pitch” highlighting the value of your design. The value of your design should include the purpose of the design, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future.

Resources: World’s Fairs. (2015). Calendar of Events. Retrieved 06/02, 2016, from <http://worldsfairs.com/calendar-links/>

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Financial Record - p. 2

Starting budget	
After Purchases	
After event #1	
After Purchases	
After event #2	
After Purchases	
After event #3	
After Purchases	
After event #4	
After Purchases	
After event #5	
After Purchases	
After event #6	
After Purchases	
After event #7	
After Purchases	
After event #8	
After Purchases	
After event #9	
After Purchases	
After event #10	
After Purchases	
After event #11	
After Purchases	
After event #12	
After Purchases	
Remaining money in budget	

The Challenge:

Design and build one section (hole) of a mini- golf course on a budget supplied by your firm. Teams must purchase necessary supplies for their build with this budget, but will encounter various factors that will influence available resources. The end result should be a mini-golf experience that is enjoyable for the golfers of all ages and would attract family business.

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8. Creativity and attention to purpose is encouraged. Be innovative in designs.

Every team will receive: 1 roll of masking tape, 1 yard stick, 1 golf ball, 1 golf club, 3 pairs of scissors, access to painters tape for marking off the team's area of play

Challenge modified from: Kingore, B. (1998). *Engaging Creative Thinking*, (pp. 51-62). Austin, TX: Professional Associates Publishing.

Steps:	Move on only as directed to by the teacher:	Questions to ask and answer to successfully rise to the challenge
1	As a team, brainstorm by sharing ideas of what your section could look like.	What are possible ways to make sure that all build requirements are met? What materials are affordable with the monetary resources that we have available? Make various sketches as needed to share your ideas. What challenges could be presented to the players?
2	Design a plan that incorporates your best ideas and meets the requirements. See teacher for painters tape to mark off your 8-12 sq. ft. for your hole with painters tape.	What hazards can be engineered to cause a changed in the ball's direction while in motion? What will cause a change in the ball's elevation on its way to the hole? How does this plan work for our purpose?
3	Come up with a financial plan.	What supplies can we afford with our current budget? Make sure to take into account the current cost and the number of each supply needed. Is there another option that would be more cost effective? What financial resources should we keep on reserve for situations that may arise during our build?
4	Make purchases when your team is called by the Supply Master. Each team will have the opportunity to purchase one type of supply at a time.	What supplies are most important to purchase? What supplies should be purchased first?
5	Every time an event occurs, make adjustments to prices or budget. Adjust plans and purchases depending upon the resources you have available as well as changes in cost. Continue to make purchases when allowed until all needed supplies are acquired.	Have we adjusted prices and our budget as necessary on our Financial Record? If you can no longer afford needed supplies, what adaptions can you make to your plan? What substitutions can be made for building supplies? How can you apply your innovation skills to make needed changes?
6	Once your team has enough supplies purchased, you can begin your build and add on as supplies are purchased.	Do we have the necessary components to begin the build? Will beginning the build at this point compromise the integrity if the build?
7	When build is complete test your hole. Make sure that all requirements are met.	Has the change in direction and elevation been incorporated? Does the ball stay on the green and does it stop once it goes in the hole?
8	Put together a final report of your team's budget and expenses.	
9	Each team member should play through the hole and record the scores	
10	As a team, determine what par for the hole will be. Par should not be lower than the lowest score any team member scored.	What would be a fair par for this hole?
11	Post a sign with your firm name showing what Par for your hole is.	



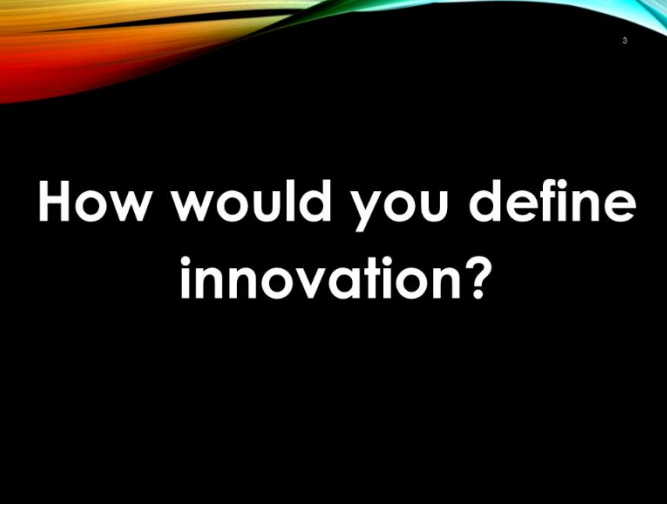
1

WELCOME TO... EVERYDAY ENGINEERS DAY 2



2

MINI-GOLF CHALLENGE



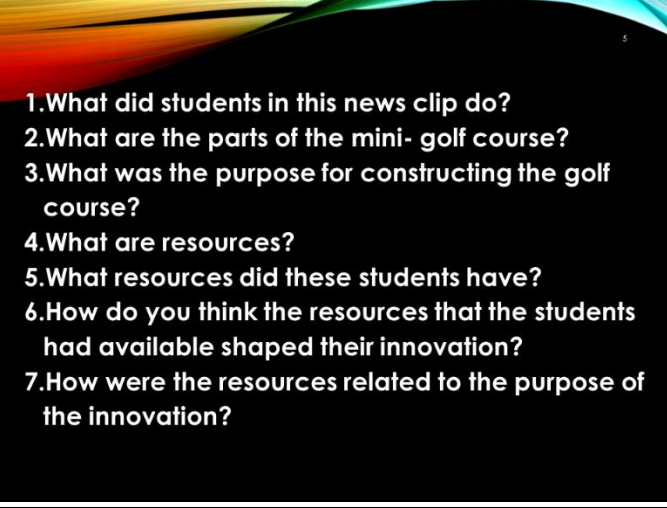
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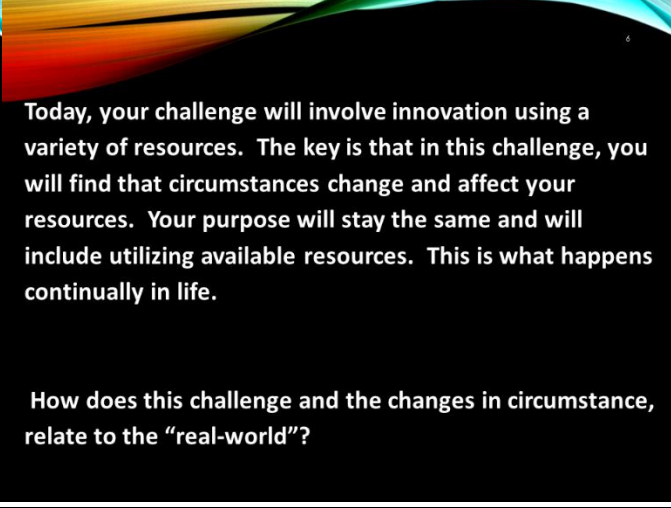
How would you define innovation?



4

<http://www.bigcountryhomepage.com/news/ktab-news/students-create-cardboard-mini-golf-course-for-charity>

- 
- 5
- 1.What did students in this news clip do?
 - 2.What are the parts of the mini- golf course?
 - 3.What was the purpose for constructing the golf course?
 - 4.What are resources?
 - 5.What resources did these students have?
 - 6.How do you think the resources that the students had available shaped their innovation?
 - 7.How were the resources related to the purpose of the innovation?



6

Today, your challenge will involve innovation using a variety of resources. The key is that in this challenge, you will find that circumstances change and affect your resources. Your purpose will stay the same and will include utilizing available resources. This is what happens continually in life.

How does this challenge and the changes in circumstance, relate to the “real-world”?

Challenge

Your engineering firm is vying for a contract to build a new mini-golf course here in Durham. This contract is a big deal, because it could lead to a contract for a chain of new mini-golf courses that will be built throughout the country. Several firms have proved that they would do a fantastic job designing the course, so to help decide who will be awarded the contract, the company has set up a competition. Each engineering firm has put together a team of their best designers and you have been chosen as a member.

It is up to your team to play by the rules of the contest and create an innovative design that will sway the company executives so they will pick your firm for the contract. The purpose of the new mini-golf course will be to attract customers from the surrounding area as well as tourist. It will be marketed as family friendly business with a course that is exciting and challenging for all ages. Keep this purpose in mind as you strive to create the most innovative and exciting hole possible.

The Challenge:

Design and build one section (hole) of a mini-golf course on a budget supplied by your firm. Teams must purchase necessary supplies for their build with this budget, but will encounter various factors that will influence available resources. The end result should be a mini-golf experience that is enjoyable for the golfers of all ages and would attract family business.

Build Requirements

The section for each hole (entire area of play) must be less between 8 and 12 square feet and should be taped off using painters tape.

Ball must travel a change of elevation (go up or down) in order to reach the hole.

Ball must change direction through turns or bends in the course as it travels to reach the hole.

Barriers should be constructed to keep the ball from traveling out of the designated green for the hole.

The hole must be designed so the ball will stop and not fall, roll, or bounce out.

Only materials on the available supplies list may be used. (included list is a guess as available supplies may vary depending upon resources I can collect)

Supplies must all be purchased with team funds at the current price, unless a "Turn of Event" card denotes otherwise.

An accurate record of team funds, purchases, and supplies must be kept.

Team Guidelines:

Students work in groups of 2-3 people.

Groups must work cooperatively and respectfully.

One team member should be responsible for recording on the purchase order and conducting purchases.

All team members are responsible for accurate calculations and participating in all aspects of the planning and build.

Materials may not be shared among groups.

Students should only touch their own team's build and materials.

Each group must clean up their work area.

Creativity and attention to purpose is encouraged. Be innovative in designs.

Every team will receive: 1 roll of masking tape, 1 yard stick, 1 golf ball, 1 golf club, 3 pairs of scissors, access to painters tape for marking off the team's area of play.

The teams will follow the following schedule of events, but after the first 15 minutes, the students will be interrupted for a turn of events every 7 to 10 minutes.

During the turn of event, a representative from each team will roll a die and record the number on the Turn of Events Chart on the board.

One card will be drawn from the Turn of Event cards and posted with the corresponding event.

The Turn of Event card will be applicable to teams that rolled either even or odd numbers, depending upon the notation on the Turn of Events Card.

The card will be posted on the chart in the row for that event and all affected teams, must make needed changes on their Purchasing Record.

All prices and budgets will be affected from that point on in the project unless otherwise noted.

Steps:	Move on only as directed to by the teacher:	Questions to ask and answer to successfully rise to the challenge
1	As a team, brainstorm by sharing ideas of what your section could look like.	What are possible ways to make sure that all build requirements are met? What materials are affordable with the monetary resources that we have available? Make various sketches as needed to share your ideas. What challenges could be presented to the players?
2	Design a plan that incorporates your best ideas and meets the requirements. See teacher for painters tape to mark off your 8-12 sq. ft. for your hole with painters tape.	What hazards can be engineered to cause a change in the ball's direction while in motion? What will cause a change in the ball's elevation on its way to the hole? How does this plan work for our purpose?
3	Come up with a financial plan.	What supplies can we afford with our current budget? Make sure to take into account the current cost and the number of each supply needed. Is there another option that would be more cost effective? What financial resources should we keep on reserve for situations that may arise during our build?
4	Make purchases when your team is called by the Supply Master. Each team will have the opportunity to purchase one type of supply at a time.	What supplies are most important to purchase? What supplies should be purchased first?
5	Every time an event occurs, make adjustments to prices or budget. Adjust plans and purchases depending upon the resources you have available as well as changes in cost. Continue to make purchases when allowed until all needed supplies are acquired.	Have we adjusted prices and our budget as necessary on our Financial Record? If you can no longer afford needed supplies, what adaptations can you make to your plan? What substitutions can be made for building supplies? How can you apply your innovation skills to make needed changes?
6	Once your team has enough supplies purchased, you can begin your build and add on as supplies are purchased.	Do we have the necessary components to begin the build? Will beginning the build at this point compromise the integrity of the build?
7	When build is complete test your hole. Make sure that all requirements are met.	Has the change in direction and elevation been incorporated? Does the ball stay on the green and does it stop once it goes in the hole?
8	Put together a final report of your team's budget and expenses.	
9	Each team member should play through the hole and record the scores.	
10	As a team, determine what par for the hole will be. Par should not be lower than the lowest score any team member scored.	What would be a fair par for this hole?
11	Post a sign with your firm name showing what Par for your hole is.	

Available Supplies	Number needed	Starting Cost /unit	Cost after Event #1	Cost after Event #2	Cost after Event #3	Cost after Event #4	Cost after Event #5	Cost after Event #6	Cost after Event #7	Cost after Event #8	Cost after Event #9	Cost after Event #10	Cost after Event #11	Cost after Event #12	Price Per Foot	Total number purchased	Total Cost of Materials
18 butcher paper		30c															
18 Landscape Fabric		40c															
Paper towel Roll		20c															
1/2" Cardboard tubing		10c															
Shoe Box		40c															
Small Box		10c															
Medium Box		20c															
Large Box		30c															
1 ft twine or yarn		30c															
1 can		10c															
1 cap		10c															
18 packing tape		20c															
1/2" black tubing		50c															
1 in wide tubing		30c															
2 ft of large cardboard		40c															

1. How does purpose influence innovation?
2. How did the purpose influence your design?
3. What innovations did you come up with to fulfill the requirements of the hole?
4. What build designs did you find particularly resourceful and why?
5. Why did you choose the original supplies on your purchase request list?
6. What challenges did you face in the building process?
7. How did you feel when the Turn of Event cards did or didn't make a difference for your team?
8. What difference did the Turn of Event cards make in your resources?
9. How did your resources influence the supplies you were able to purchase?
10. In what ways did your resources shape your innovation?
11. What forces influence the ball directions on your hole?
12. After playing all holes, in what ways do you think other teams' resources shaped their innovation?
13. How do you think resources influence innovation?

12

Resources

Big Country Homepage.com. (2012). Students create cardboard mini golf course for charity. Retrieved 3/31, 2016 from <http://www.bigcountryhomepage.com/news/ktab-news/students-create-cardboard-mini-golf-course-for-charity>

Kingore, B. (1998). Engaging Creative Thinking, (pp. 51-62). Austin, TX: Professional Associates Publishing.

References

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TEACHER NAME		Lesson #
Laura Pryor		3 (Day 3)
MODEL	CONTENT AREA	GRADE LEVEL
Creative Problem Solving	Science	5 th
CONCEPTUAL LENS		LESSON TOPIC
Innovation		Bridge Design
LEARNING OBJECTIVES (from State/Local Curriculum)		
5.P.1 – Understand force, motion and the relationship between them. 5.P.1.1 Explain how factors such as gravity, friction, and change in mass affect the motion of objects. 5.P.1.4 Predict the effect of a given force or a change in mass on the motion of an object. 7.P.1.2 Explain the effects of balanced and unbalanced forces acting on an object 5.MD.1 Convert among different-sized standard measurement units within a given measurement system and use these conversions in solving multi-step, real world problems. 5.V.2.1 Evaluate solutions to artistic problems, including their effectiveness		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to “uncover” the Essential Understanding)
Purpose influences innovation		How does purpose influence innovation?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know... - That the job of an engineer is to use math and science in designs and creations that help solve real-world problems. - That science and math concepts are useful and necessary in designing and building. - That forces such as gravity, compression, and tension can be used in real-world designs. - That innovation can come from an original idea or improvement on someone else's design.		Students will be able to ... - Apply concepts from science and math during design and construction. - Analyze problems and persevere in solving them. - Apply understanding of new concepts while creating a new design and structure. - Construct viable arguments & critique the reasoning of others. - Reason abstractly and quantitatively.
GUIDING QUESTIONS What questions will be asked to support instruction? Include both “lesson plan level” questions as well as questions designed to guide students to the essential understanding		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
What is the purpose of a bridge? What differences do you see in the support that bridges need? Why do some bridges need extra supports added? How does the needing extra supports on a bridge relate to purpose? How does this purpose influence the innovation used when designing the bridge? What does free standing mean? How does the intended use of the bridge effect the design or how strong it needs to be? What innovative designs were used to meet the purpose of the bridge? What was the purpose of building a bridge here? How does this relate to purpose? What things should be considered when coming up with a design? How does purpose influence innovation? Who designs a bridge? What does an engineer do? What is innovation? What would make a bridge design innovative? What drives innovation?	What features would be useful to use in our bridge, considering the materials we have available? What design features were consistent in the bridges? What happens if the forces are balanced? Unbalanced? How would tension and compression be relevant to bridge design? How are tension and compression related to the purpose of this bridge? How did we see tension or compression used? How was the design of this bridge innovative? What problems might we face? What is the purpose of this bridge? What is the challenging part of this task? How can the materials be manipulated in various ways to increase strength? Which manipulations are the strongest? Which manipulations of the materials would help create a strong bridge of the appropriate size? How does our purpose influence our innovation in design? How does this plan work for our purpose? How can the forces acting upon the bridge be balanced? How will the resources match with the resources needed for the bridge you proposed? What other resources might we need?	Why did you decide to use this design? What innovative ideas did you use in this plan? How did these innovations help fulfill the purpose of the bridge? What challenges did you face in the building process? How did you use innovative ideas to meet the challenges? How did the purpose of the bridge influence the innovations you came up with? What forces are at work in your bridge with and without weight added to it? What math concepts did you use during the building process? What was your favorite thing about this challenge? What would you change about this challenge? What was the most memorable lesson you learned from this challenge? How do you think purpose influences innovation?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.)

Content	Process	Product	Learning Environment
Concepts are introduced and explored that are advanced for this age group. (from 7 th grade curriculum) - balance and unbalance forces - compression and tension	This creative problem solving lesson gives advanced learners the opportunity to continue to grow through the alternating use of divergent and convergent thinking. Students have multiple opportunities to exercise their creative abilities and gifts.	The student products will vary according to the various abilities of those in each group. This is beneficial for allowing gifted learners to incorporate what they know into the product while allowing them to grow through exploration and innovation.	Students will be clustered with other gifted learners. They will work in student lead collaborative groups.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

ENGAGE AND CONNECT - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students. **(20 minutes)**

As students enter room, count them off in numbers to put them into groups. (3-4 in each group) Have them sit in those groups.

Show students a PowerPoint of landscape pictures that all include bridges. Ask students to pick out similarities in the pictures. Discuss the purpose of a bridge in general and then of a few of the bridges in the pictures. What is the purpose of a bridge? What differences do you see in the support that bridges need? Why do some bridges need extra supports added? How does the needing extra supports on a bridge relate to purpose? How does this purpose influence the innovation used when designing the bridge? What does free standing mean? How does the intended use of the bridge effect the design or how strong it needs to be? What innovative designs were used to meet the purpose of the bridge?

View the Impossible Bridge video at <http://www.sciencekids.co.nz/videos/engineering/bridgebuilding.html>

What was the purpose of building a bridge here? How does this relate to purpose? What things should be considered when coming up with a design? How does purpose influence innovation? Who designs a bridge? Does the engineer need to actually build the bridge? What does an engineer do? What is innovation? What would make a bridge design innovative? What drives innovation?

EXPLORE - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Mess Finding: (challenge and guidelines are projected and handed out for groups to refer to during process) (5 minutes)

Students are challenged to build a strong bridge that will meet requirements while using the provided supplies.

Purpose of bridge: to hold 4 lbs. for one minute on the bridge (not the support)

Requirements: 12" long, at least 6" tall, free standing, strong enough to hold 4lbs for one minute

Supplies that can be used for construction: two inch stack of newspapers, one roll of masking tape

Tools that may be used, but not part of the actual bridge: 12 inch ruler, scissors, writing utensils

Guidelines:

1. Students work in groups of 2-3 people.
2. Groups must work cooperatively and respectfully
3. Materials may not be shared among groups
4. Students should only touch their own groups bridge and materials
5. Each group must clean up their work area.
6. Creativity and attention to purpose is encouraged. Be innovative in designs.

Data Finding: (10 minutes)

Groups look over pictures of bridges to observe the forces being applied and way these forces are utilized or overcome in the bridge designs.

Include all ideas. Then think about, imagine, share, and discuss which of the design principals might be incorporated into the task. What features would be useful to use in our bridge, considering the materials we have available? What design features were consistent in the bridges?

EXPLAIN - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

(15 minutes) What forces may impact bridges or may be used in the design of bridges? Students will likely make suggestions such as gravity and friction. Note the way weight and gravity would influence a bridge. The forces that contribute to weathering may also be suggested, and would influence design and materials used in the real world.

Introduce the concept of compression (pushes) and tension (pulls) through a short partner activity.

1. Facing each other, partners should put their arms straight out in front of them with palms facing each other. Students should push their palms together while leaning toward each other. Each person can take a step backwards while leaning toward their partner. Their bodies will make an arch. The teacher will apply force on the arms (bridge) to increase the compression (push) that each person is applying.
2. Facing each other, partners should grasp each other's forearms just past the wrist. Move feet together so your toes are touching your partners'. Now lean back and let the tension (pull) from your partner keep you from falling. Once again, the teacher will press down on the partner's arms to increase the tension.

After each position, discuss the forces at work. What happens if the forces are balanced? Unbalanced? How would tension and compression be relevant to bridge design? How are tension and compression related to the purpose of this bridge? Watch this short video.

<http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfw.bbsuspension/clifton-suspension-bridge/>

How did we see tension or compression used? How was the design of this bridge innovative?

Problem Finding: (10 minutes)

Students have the opportunity to experiment with sample materials. This is essentially a brainstorming time for use of materials, without actually building anything. Students should see how they can manipulate the given materials to withstand extra tension and compression. Students are encouraged to be innovative in how they can use their materials and ideas they have gained from the pictures of bridges. Ideas for manipulating materials are: folding, braiding, twisting, layering, rolling, and wadding. These sample materials will not be kept by the group, or used in the construction of the bridge. They will be able to look at it for a reference.

The following questions will be projected on the overhead for groups to ask themselves as they experiment with materials.

What problems might we face?

What is the purpose of the bridge?

What is the challenging part of this task?

How can the materials be manipulated in various ways to increase strength?

Which manipulations are the strongest?

Which manipulations of the materials would help create a strong bridge of the appropriate size?

Idea Finding: (10 minutes)

Teams now sketch designs or blueprints that include their innovative ideas. All ideas are welcome and students are encouraged to piggy-back on the ideas of other students as part of working as a team. Students should be as creative as possible and give as many ideas as they can with constant consideration of the purpose for the bridge. How does our purpose influence our innovation in design?

ELABORATE —Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

Solution Finding: (10 minutes)

Teams now look at all the design plans, working through the pros and cons of each, while evaluating for effectiveness.

Teams are encouraged to ask themselves:

How does this plan work for our purpose?

How can the forces acting upon the bridge be balanced?

How will the resources match with the resources needed for the bridge you proposed?

What other resources might we need?

The best design is chosen for implementation. If design flaws were seen during evaluation, or ideas for improvements were given, the design is updated to reflect the best plan of action. Designs can be combined for an optimum design.

Acceptance Finding: (60-75 minutes)

Construction begins as groups divvy up tasks to each group member and plan their course of action. Allow approximately 60 minutes for construction. As the groups progress, adjust allotted time for construction as needed. As groups are working, note how individuals and groups are working together. Note behaviors on rubric below for assessment.

Ask questions such as:

Why did you decide to use this design?

What innovative ideas did you use in this plan?

How did these innovations help fulfill the purpose of the bridge?

EVALUATE - This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.

Once groups have completed their bridges, each group will have a chance to share their bridges with the class. **(20 minutes)** Each group will describe their bridge, the reason for their design. Students should answer the questions below.

What challenges did you face in the building process?

How did you use innovative ideas to meet the challenges?

How did the purpose of the bridge influence the innovations you came up with?

What forces are at work in your bridge with and without weight added to it?

What math concepts did you use during the building process?

The group's bridge will then be measured to make sure it follows the requirements. Weights will be added until the bridge holds four pounds. If the bridge stands for one minute, the group met the challenge. Each group may choose to have more weights added to see how much the bridge will hold just for fun.

Once all groups have shared, students will separate and individually evaluate themselves and their group members on the rubric below. **(10 minutes)**

The challenge:

Build a strong bridge that will meet requirements while using the provided supplies.

Purpose of bridge: to hold 4 lbs. for one minute on the bridge (not the support)

Requirements: 12'' long, at least 6'' tall, free standing, strong enough to hold 4lbs for one minute

Supplies that can be used for construction: two inch stack of newspapers, one roll of masking tape

Tools that may be used, but not part of the actual bridge: 12 inch ruler, scissors, writing utensils

Guidelines:

1. Students work in groups of 2-3 people.
2. Groups must work cooperatively and respectfully
3. Materials may not be shared among groups
4. Students should only touch their own groups bridge and materials
5. Each group must clean up their work area.
6. Creativity and attention to purpose is encouraged. Be innovative in designs.

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Questions for Material Experimentation:

What problems might we face?

What is the purpose of the bridge?

What is the challenging part of this task?

How can the materials be manipulated in various ways to increase strength?

Which manipulations are the strongest?

Which manipulations of the materials would help create a strong bridge of the appropriate size?

Solution Finding:

Look at all your design plans.

Work through the pros and cons of each, while evaluating for effectiveness.

To do this, ask yourselves:

1. How does this plan work for our purpose?
2. How can the forces acting upon the bridge be balanced?
3. How will the resources match with the resources needed for the bridge you proposed?
4. What other resources might we need?

After Bridge Design:

Once you have completed your bridge, you will share it with the class. Be prepared to describe your bridge and the reason for your design.

Be prepared to answer the questions below:

1. What challenges did you face in the building process?
2. How did you overcome these challenges?
3. How did the purpose of the bridge influence the innovations you came up with?
4. What forces are at work in your bridge with and without weight added to it?
5. What math concepts did you use during the building process?

CREATIVE-COLLABORATIVE TASK RUBRIC

My Name _____

Circle One: Self-Assessment Peer Assessment Teacher Assessment

Assessment of _____

Date _____

Score /28

CATEGORY	4	3	2	1
Creativity X2	Routinely shares unique, insightful, or useful ideas with the group	Shares ideas that improve upon other's ideas (piggy-backing) or is able to creatively combine multiple ideas	Ideas shared with group are typical or show little original thinking	Does not contribute ideas to the group.
Problem-Solving X2	Actively suggest high-level solutions to problems. Use of innovation, synthesis, or evaluation is evident.	Actively suggest solutions to problems. Use of appropriate problem solving process including analysis and application is evident.	Attempts problem solving, but is incomplete in application. Demonstrates trouble with logical steps.	Does not try to solve problems.
Listening, Questioning, and Discussing	Respectfully listens, interacts, discusses and helps direct the group in reaching consensus.	Respectfully listens, interacts, discusses and poses questions to others during discussions.	Has some difficulty respectfully listening and discussing, and/or tends to dominate discussions.	Does not listen to others, argues with group, and is unwilling to consider other opinions.
Focus on the Task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Must be reminded to keep on task.	Rarely focuses on the task and what needs to be done. Allows others to do the work.
Group Participation and Teamwork	A strong team member who contributes a lot of effort while encouraging and supporting the efforts of others in the group.	A strong group member who continually puts for the effort.	A satisfactory group member who does what is required most of the time.	A weak team member who sometimes chooses not to participate or complete assigned tasks.

Rubric adapted from: Kingore, B. (1998). Engaging Creative Thinking, (pp. 39). Austin, TX: Professional Associates Publishing.

What was your favorite thing about this challenge?

What would you change about this challenge?

What was the most memorable lesson you learned from this challenge?

How do you think purpose influences innovation?

CREATIVE-COLLABORATIVE TASK RUBRIC

My Name _____

Circle One: Self-Assessment Peer Assessment Teacher Assessment

Assessment of _____

Date _____

Score _____ /28

CATEGORY	4	3	2	1
Creativity X2	Routinely shares unique, insightful, or useful ideas with the group	Shares ideas that improve upon other's ideas (piggy-backing) or is able to creatively combine multiple ideas	Ideas shared with group are typical or show little original thinking	Does not contribute ideas to the group.
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This PowerPoint for Day 3 is a modified form of the slide show below:

Brenner, B., Levine, A., & Tran, C (2016) Bridges. Retrieved 04/05, 2016, from <http://slideplayer.com/slide/5746440/>

WELCOME TO... EVERYDAY ENGINEERS DAY 3

BRIDGES



Adapted from PowerPoint by
Brian Brenner
Aaron Levine
Cindy Tran

<http://slideplayer.com/slide/5746440/>



SOME USES OF BRIDGES³

- Walkways
- Highways/Roads
- Railways
- Pipelines
- Connecting lands
- Crossing rivers and canyons



TYPES OF BRIDGES⁴

- Arch
- Truss
- Cantilever
- Cable-Stayed
- Suspension



OTHER TYPES⁵



Truss
Southern Pacific Railroad Bridge,
Tempe, AZ



Cantilever
Firth of Forth-Forth Rail Bridge,
Edinburgh, Scotland

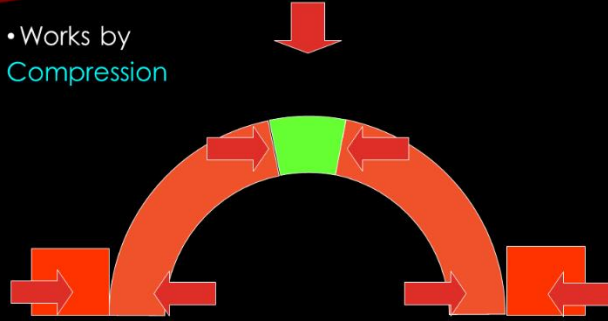
WHAT MAKES A BRIDGE STAY UP?⁶

- Forces
 - **Compression** – a pushing or squeezing force
 - **Tension** – a pulling or stretching force
- Demonstration
 - Make groups of two...



ARCH BRIDGES⁸

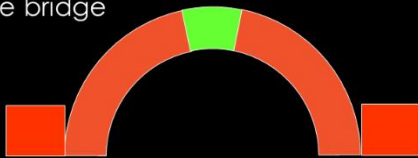
- Works by
Compression



Cold Spring Arch Bridge, Santa Barbara, CA

ARCH BRIDGES⁹

- **Keystone** – the wedge-shaped stone of an arch that locks its parts together
- **Abutments** – the structures that support the ends of the bridge



Marsh Rainbow Arch, Riverton, KS



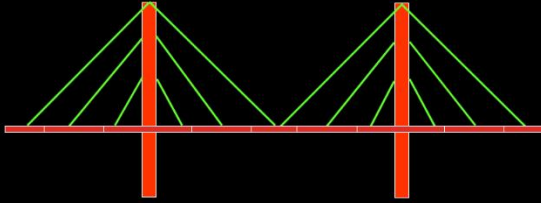
Pont du Gard, Nimes, France



Sunshine Skyway Bridge, Tampa, FL

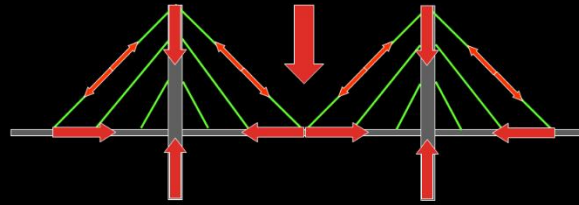
CABLE-STAYED BRIDGES

- **Piers** – the vertical supporting structures
- **Cables** – thick steel ropes from which the decking is suspended
- **Decking** – the supported roadway on a bridge

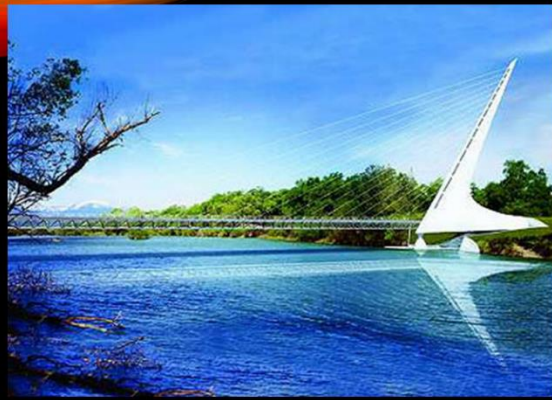


CABLE-STAYED BRIDGES

- Works by **Tension** AND **Compression**



Zakim Bridge, Boston, MA



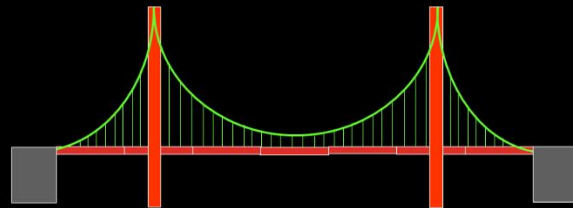
Sundial Bridge, Redding, CA



Golden Gate Bridge, San Francisco, CA

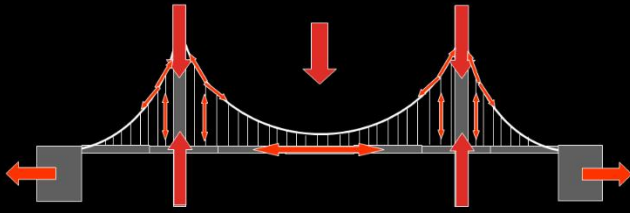
SUSPENSION BRIDGES

- Similar to Cable-Stayed
- Different construction method

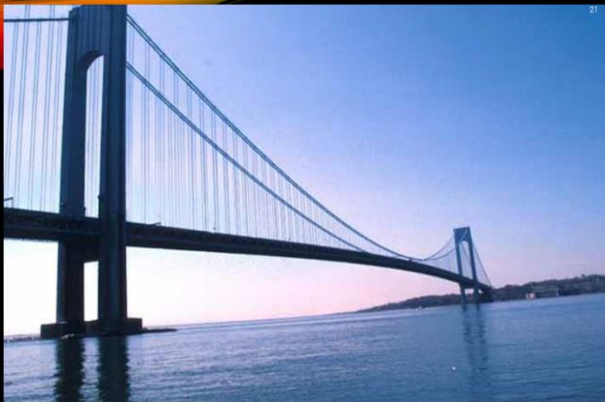


SUSPENSION BRIDGES

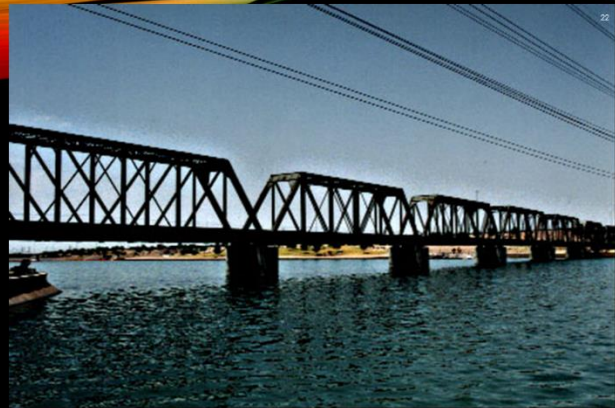
- Works by **Tension** and **Compression**



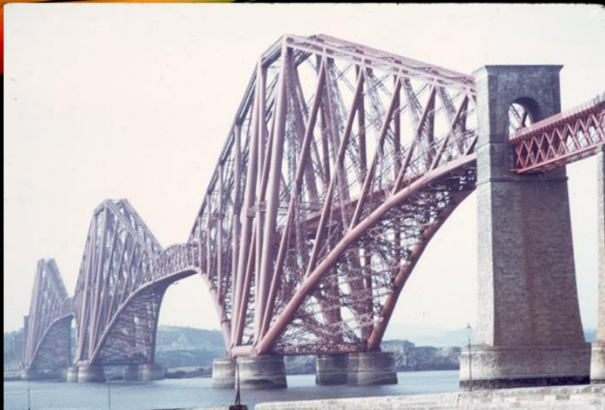
Brooklyn Bridge, Brooklyn, NY



Verrazano-Narrows Bridge, New York, NY

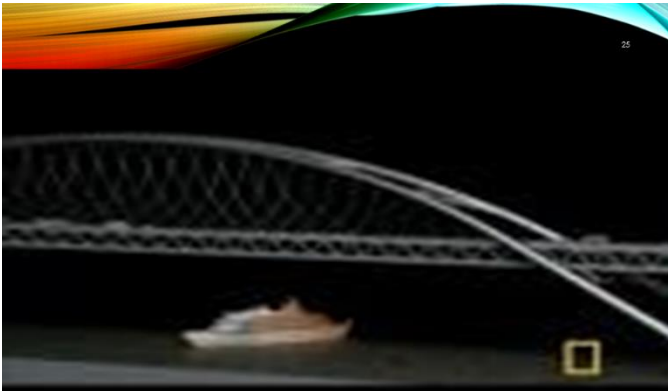


Southern Pacific Railroad Bridge, Tempe, AZ



FIRTH OF FORTH-FOORTH RAIL BRIDGE, EDINBURGH, SCOTLAND

- ❖ What is the purpose of a bridge?
- ❖ What differences do you see in the support that bridges need?
- ❖ Why do some bridges need extra supports added?
- ❖ How does the needing extra supports on a bridge relate to purpose?
- ❖ How does this purpose influence the innovation used when designing the bridge?
- ❖ What does free standing mean?
- ❖ How does the intended use of the bridge effect the design or how strong it needs to be?
- ❖ What innovative designs were used to meet the purpose of the bridge?



<https://www.youtube.com/watch?v=yLZYETImM>

WHO DESIGNS BRIDGES?

- Engineers - they use math and science to solve real world problems (like crossing a river)
- Civil engineers – design and build bridges, roadways, tunnels, buildings, dams, etc.

Civil Engineer



How do engineers solve real world problems?

Innovation

THE CHALLENGE:

Build a strong bridge that will meet requirements while using the provided supplies.

Purpose of bridge: to hold 4 lbs. for one minute on the bridge (not the support)

Requirements: 12" long, at least 6" tall, free standing, strong enough to hold 4 lbs for one minute

Supplies that can be used for construction: two inch stack of newspapers, one roll of masking tape

Tools that may be used, but not part of the actual bridge: 12 inch ruler, scissors, writing utensils

GUIDELINES:

- Students work in groups of 3-4 people.
- Groups must work cooperatively and respectfully
- Materials may not be shared among groups
- Students should only touch their own group's bridge and materials
- Each group must clean up their work area.
- Creativity and attention to purpose is encouraged. Be innovative in designs.

MATERIAL BRAINSTORMING

- What problems might we face?
- What is the purpose of the bridge?
- What is the challenging part of this task?
- How can the materials be manipulated in various ways to increase strength?
- Which manipulations are the strongest?
- Which manipulations of the materials would help create a strong bridge of the appropriate size?

**SKETCH DESIGNS
OR BLUEPRINTS THAT
INCLUDE YOUR
INNOVATIVE IDEAS**

5 MINUTES

31

**LOOK AT ALL THE DESIGN PLANS.
WORK THROUGH THE PROS AND
CONS OF EACH, WHILE EVALUATING
FOR EFFECTIVENESS. CHOOSE
WHICH PLAN YOU WILL USE. (5
MINUTES)**

To do this, ask yourselves:

- How does this plan work for our purpose?
- How can the forces acting upon the bridge be balanced?
- How will the resources match with the resources needed for the bridge you proposed?
- What other resources might we need?

32

CREATE YOUR BRIDGE

50 Minutes

Starting Now: <http://www.online-stopwatch.com/full-screen-stopwatch/>

33

CLEAN UP AND ANSWER QUESTIONS FOR PRESENTATION 10 MINUTES

- What challenges did you face in the building process?
- How did you use innovative ideas to meet the challenges?
- How did the purpose of the bridge influence the innovations you came up with?
- What forces are at work in your bridge with and without weight added to it?
- What math concepts did you use during the building process?

34

RESOURCES

THIS IS A MODIFIED FORM OF THE SLIDE SHOW BELOW:

BRENNER, B., LEVINE, A., & TRAN, C (2016) BRIDGES. RETRIEVED 04/05, 2016, FROM [HTTP://SLIDEPLAYER.COM/SLIDE/5746440/](http://SLIDEPLAYER.COM/SLIDE/5746440/)

<HTTPS://WWW.YOUTUBE.COM/WATCH?v=YLZYETLMM>

References

Brenner, B., Levine, A., & Tran, C (2016) Bridges. Retrieved 04/05, 2016, from <http://slideplayer.com/slide/5746440/>

Discovery "E". (2016). Suspension bridge. Retrieved 04/05, 2016 from <http://www.reachoutmichigan.org/funexperiments/quick/eweek/suspbridge.html>

Kingore, B. (1998). Engaging Creative Thinking, (pp. 31-37). Austin, TX: Professional Associates Publishing.

PBS Learning Media. (2016). Clifton suspension bridge. Retrieved 04/05, 2016 from <http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfw.bbsuspension/clifton-suspension-bridge/>

Science Kids. (2016). Engineering videos. Retrieved 04/05, 2016 from <http://www.sciencekids.co.nz/videos/engineering/bridgebuilding.html>

TEACHER NAME		Lesson #
Laura Pryor		4 (Day 4)
MODEL	CONTENT AREA	GRADE LEVEL
Visual Thinking Strategy	ELA/Science	4 th /5 th
CONCEPTUAL LENS		LESSON TOPIC
Innovation		Innovation in Pictures
LEARNING OBJECTIVES (from State/Local Curriculum)		
ELA RL.4.1- Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. RL.4.3 Describe in depth a character, setting, or event in a story or drama, drawing on specific details in the text (e.g., a character's thoughts, words, or actions) W.4.3 Write narratives to develop real or imagined experiences or events using effective technique, descriptive details, and clear event sequences. Use concrete words and phrases and sensory details to convey experiences and events precisely. SL.4-5.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4-5 topics and texts, building on others' ideas and expressing their own clearly. SL.5.2. Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally. 4.V.1.3 Infer meaning from art. 5.CX.2.4 Interpret visual images from media sources and the immediate environment. 5.v.2.Apply creative and critical thinking skills to artistic expression		
THE ESSENTIAL UNDERSTANDING (What is the overarching idea students will understand as a result of this lesson?)		THE ESSENTIAL QUESTION (What question will be asked to lead students to "uncover" the Essential Understanding)
Purpose influences innovation		How does purpose influence innovation?
CONTENT KNOWLEDGE (What factual information will students learn in this lesson?)		PROCESS SKILLS (What will students be able to do as a result of this lesson?)
Students will know... • That innovation involves ideas that are new and valuable • That visual images tell stories • That visual images can be interpreted in multiple ways • Captions are vital in accurate understanding of pictures • Communication can be achieved through images and the written word • Collaboration with others gives opportunity to build on other's ideas and grow in our own understanding		Students will be able to ... • Analyze images to create understanding • Interpret details and expression to infer meaning • Collaborate with various groups to build on others' ideas • Construct viable arguments and critique the reasoning of others • Express ideas clearly • Empathize with subjects in pictures • Speculate circumstances that lead to capturing a picture • Write captions to enhance the understanding of pictures • Apply understanding of innovation and how purpose influences innovation to understanding of pictures • Problem solve through observation, clue-finding, and drawing conclusions
GUIDING QUESTIONS What questions will be asked to support instruction? Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
What steps in the innovation process were observable in these pictures? How was purpose observable? What emotions were recognizable? If you had not been in our class this week, what would you have been able to learn about our class through this slide show? If you had not been in our class this week, but only saw the first picture, what would you have thought about our class?	What do you see happening in this picture? What do you see that makes you say that? What else can you find in this picture? How does this picture make you feel? How do you think those pictured feel? Why do you think that? How is innovation relevant to this picture? What purpose do you speculate these children had? How can you explain the influence of that purpose on the innovation?	What do you see happening in this picture? What do you see that makes you say that? What else can you find in this picture? Who do you think took this picture? What is important in this picture? What makes you think it is important? What does the setting tell you? How does this picture make you feel? How do you think the person in the picture feels? Why do you think that? How is innovation relevant to this picture? What purpose could be behind the creation in the picture? How does purpose influence the innovation shown in this picture?

DIFFERENTIATION

(Describe how the planned learning experience has been modified to meet the needs of gifted learners. Note: Modifications may be in one or more of the areas below. Only provide details for the area(s) that have been differentiated for this lesson.)

Content	Process	Product	Learning Environment
	The Visual Thinking Strategy gives students the opportunity to use higher level processing skills including analyzing, inferring, speculating, empathizing, and interpreting images to create understanding of various photographs.	The student products (captions) will vary according to the various abilities and depth of understanding.	Students will be clustered with other gifted learners. They will work in student lead collaborative groups.

PLANNED LEARNING EXPERIENCES

(What will the teacher input? What will the students be asked to do? For clarity, please provide detailed instructions)

Engage and Connect - This phase focuses on piquing students' interest and helping them access prior knowledge. This is the introduction to the lesson that motivates or hooks the students.

(5-10 minutes)

As students enter the classroom, a slide show of pictures taken of these students during the week will be projected for all to see. Once the all pictures have been viewed, ask students to watch one more time and think about the answers to the questions below:

What steps in the innovation process were observable in these pictures?

How was purpose observable?

What emotions were recognizable?

If you had not been in our class this week, what would you have been able to learn about our class through this slide show?

After students view the pictures again, have groups of 4 discuss the answers to the questions and then have each group share an answer with the class.

Then ask the class one more question: If you had not been in our class this week, but only saw the first picture, what would you have thought about our class? (The first picture will be one in which at least one student is working on an innovation, but the final product will not be clear, or it will be a picture of an unsuccessful attempt at innovation.)

Explore - In this phase, the students have experiences with the concepts and ideas of the lesson. Students are encouraged to work together without direct instruction from the teacher. The teacher acts as a facilitator. Students observe, question, and investigate the concepts to develop fundamental awareness of the nature of the materials and ideas.

Show the class the picture below on the overhead. Have then study the picture for about 3 minutes silently. Ask them to try to notice the details and to keep in mind what we have been learning this week in class.



Explain - Students communicate what they have learned so far and figure out what it means. This phase also provides an opportunity for teachers to directly introduce a concept, process, or skill to guide students toward a deeper understanding.

After three minutes, begin group discussion by asking the three basic open-ended questions below. **(10-15 min discussion)**

What do you see happening in this picture?

What do you see that makes you say that?

What else can you find in this picture?

How does this picture make you feel?

How do you think those pictured feel?

Why do you think that?

As students answer, teacher rephrases the responses to make sure they are understanding the comment correctly and also points to specific areas that comments are referring to. Clarifying questions may be asked, summaries of overall responses given, and relationships of multiple comments noted. Teacher's body language and facial expressions should be open and encouraging, without judging tones.

If students do not broach the answers to the following questions without prompting, ask them before concluding the discussion.

How is innovation relevant to this picture?

What purpose do you speculate these children had?

How can you explain the influence of that purpose on the innovation?"

Lead the class to write a 2-3 sentence caption describing the picture on how the perceived purpose influenced the innovation. **(5 minutes)**

Elaborate —Allow students to use their new knowledge and continue to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways

Students are shown the picture below on the overhead. They silently study it for approximately 3 minutes.



Students meet with their table groups (4 in each) to discuss the picture in the same manner in which the whole class just discussed the first picture.

Students should discuss the answers to the questions below as a group. The questions will be given to the group on paper. **(10 min discussion)**

1. What do you see happening in this picture?
2. What do you see that makes you say that?
3. What else can you find in this picture?
4. Who do you think took this picture?
5. What is important in this picture?
6. What makes you think it is important?
7. What does the setting tell you?
8. How does this picture make you feel?
9. How do you think the person in the picture feels?
10. Why do you think that?
11. How is innovation relevant to this picture?
12. What purpose could be behind the creation in the picture?

After discussion, groups should now spend **5 minutes** writing a 2-3 sentence caption for the picture including the perceived purpose and its influence on the innovation.

Evaluate: *This phase assesses both learning and teaching and can use a wide variety of informal and formal assessment strategies.*

Now groups share their answers with the whole class in discussion form as well as their captions. **(10 min discussion)**

Share with the class what the picture is actually of – a boy who was working with his siblings and mother to create a vacuum cleaner missile launcher. It did not work. Short discussion may follow.

Show the students the slideshow of pictures from this week in class again on a loop. Have them look for the one they believe is most evident of how purpose influences innovation. Have them write a 2-3 sentence caption for the picture that answers the question: How does purpose influence the innovation shown in this picture? Students will turn in the caption with the picture number to possibly use with the picture in the future. **(10-15 minutes)**

The rest of the time during the class will be used to complete performance tasks and then give presentations.

Picture for whole group.....



Picture for small groups.....



1. What do you see happening in this picture?
2. What do you see that makes you say that?
3. What else can you find in this picture?
4. Who do you think took this picture?
5. What is important in this picture?
6. What makes you think it is important?
7. What does the setting tell you?
8. How does this picture make you feel?
9. How do you think the person in the picture feels?
10. Why do you think that?
11. How is innovation relevant to this picture?
12. What purpose could be behind the creation in the picture?

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9. How do you think the person in the picture feels?
10. Why do you think that?
11. How is innovation relevant to this picture?
12. What purpose could be behind the creation in the picture?

WELCOME TO...

EVERYDAY ENGINEERS

DAY 4

- What steps in the innovation process were observable in these pictures?
- How was purpose observable?
- What emotions were recognizable?
- If you had not been in our class this week, what would you have been able to learn about our class through this slide show?

•If you had not been in our class this week, but only saw the following picture, what would you have thought about our class?





World Expo Innovation Competition

Calling all Young Innovators! Bright Minds Foundation is looking for creative, innovative, engineering designs by students to be showcased at the next World Expo. They will be traveling across the country giving students the opportunity to compete for the chance to represent the United States. To prepare for this experience, young innovators will design, build, and present their most promising and purposeful innovation.

The presented innovation should go along with the World Expo theme, "Connecting Minds, Creating the Future". The presentation should have three parts: a demonstration of a working model, a thorough description of all design parts including their function, and a "sales pitch" highlighting the value of your design. The value of your design should include the purpose of the design, how it is useful, what problem it solves or why it is an improvement upon previous designs, and how it will influence the future.

Resources - World's Fairs. (2015). Calendar of Events. Retrieved 06/02, 2016, from <http://worldsfairs.com/calendar-links/>

Resources

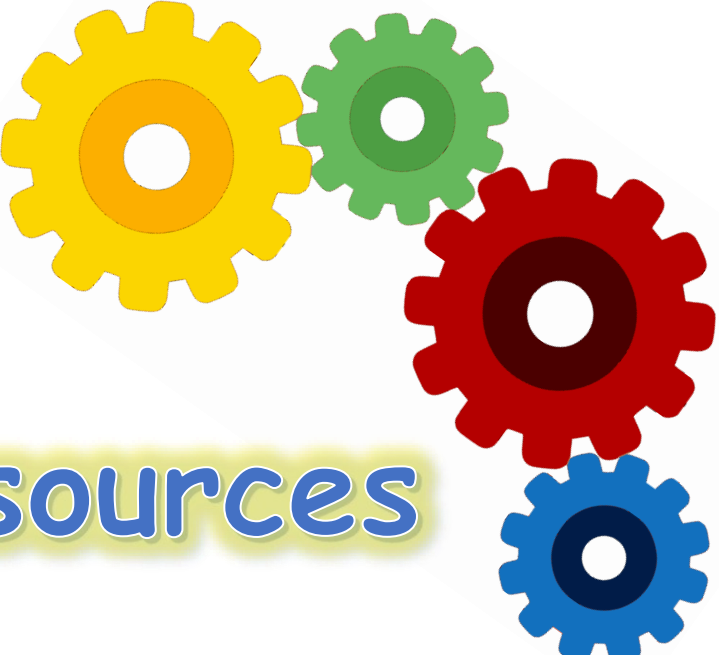
Bileski, D. (2016). Teaching kids innovation includes teaching failure. Retrieved 06/03, 2016, from <http://porridgereport.com/2012/06/02/teaching-kids-innovation-includes-teaching-failure/>

Romero, E. (2014). Think like children. Retrieved 6/3, 2016, from <http://competeoutsidethebox.com/2014/05/29/innovation-tips-be-more-like-children/>

Resources

Bileski, D. (2016). Teaching kids innovation includes teaching failure. Retrieved 06/03, 2016, from <http://porridgereport.com/2012/06/02/teaching-kids-innovation-includes-teaching-failure/>

Romero, E. (2014). Think like children. Retrieved 6/3, 2016, from <http://competeoutsidethebox.com/2014/05/29/innovation-tips-be-more-like-children/>



Unit Resources

Innovation Resources

This website has selection of different lesson plans that incorporate innovation that you can choose to explore. Some are easily accessible and others require signing up for access.

EdTechTeacher. (2016). Featured examples of innovative projects. Retrieved 08/04, 2016, from <http://edtechteacher.org/innovative/>

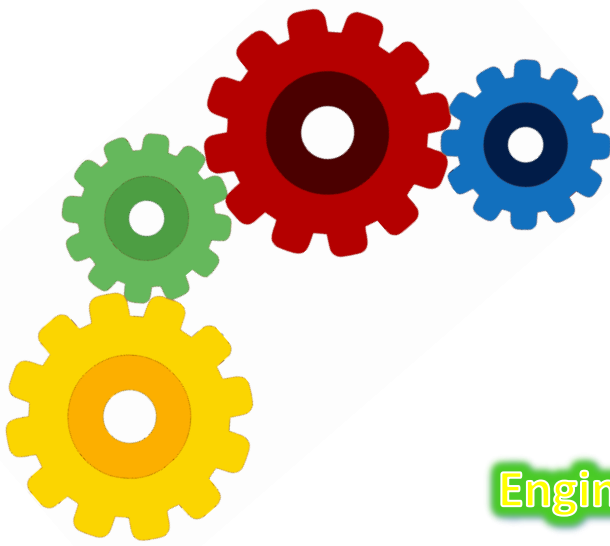
This short article is chocked full of ideas to get a teachers brain rolling. It will encourage the fostering of innovation in the classroom with new concepts and multiple resources for teacher.

Haines, R. Fostering creativity and innovation in the science classroom. LearnNC. Retrieved 08/04, 2016, from <http://www.learnnc.org/lp/pages/7028>

Prufrock is an excelent resource for educating, parenting, and being gifted. I encourage you to explore the web site to see what might interest you. The two books below both encourage creativity and innovation and are available at Prufrock.com. *Educating for Creativty and Innovation: A Comprehensive Guide for Research-Based Practice* is geared toward teachers as a resource to help them implement practices in their classroom that will draw out students creative and innovation abilities and grow them in these lifelong skills. *Engaging Creative Thinking* is a wonderful resource for teachers or parents. I utilize lesson ideas from this book for this unit.

Treffinger, D., Schoonover, P., & Selby, E. (2013). *Educating for Creativty and Innovation: A Comprehensive Guide for Research-Based Practice*, Waco, TX: Prufrock Press Inc. <http://www.prufrock.com/Educating-for-Creativity-and-Innovation-A-Comprehensive-Guide-for-Research-Based-Practice-P1664.aspx>

Kingore, B. (1998). *Engaging Creative Thinking*, (pp. 31-37). Austin, TX: Professional Associates Publishing.



Engineering Resources

Engineering is Elementary is a web site that offers curriculum products for classrooms, afterschool programs, and camps. Real-world engineering projects that incorporate current science curriculum will be sure to get students excited and motivated to problem solve.

Engineering is Elementary. (2016). Our mission. Retrieved 08/04, 2016, from <http://www.eie.org/>

The following two web sites offer lists of other websites and documents that are recommended resources. Between these two sites, students, parents, and teachers should all find relevant, useful information.

National Science Foundation. Engineering classroom resources. Retrieved 08/04, 2016, from <https://www.nsf.gov/news/classroom/engineering.jsp>

Nast, P. (2015). The 10 best STEM resources. Retrieved 08/04, 2016, from <http://www.nea.org/tools/lessons/stem-resources.html>

Bridge Lesson Plans

The following resources are lesson plans for building bridges with popcicles, straws, or cardboard and roap. All offer opportunities for students to use engineering and innovation skills.

Society for Women Engineers. Lesson: Suspension Bridge Building. Retrieved 04/05, 2016, from <http://teachers.egfi-k12.org/lesson-bridge-swe/>

TryEngineering. Popsicle Bridge Provided. Retrieved 04/05, 2016, from <http://tryengineering.org/lessons/popsiclebridge.pdf>

Lesson Plan – Straw Bridge Design Challenge. Retrieved 04/05, 2016, from <http://ubclts.com/For%20the%20web%202014/Enhanced%20practicum/2013/2nd%20group/Straw%20Bridge%20Lesson%20Plan/Straw%20Bridge%20Lesson%20Plan.pdf>

The videos links below showcase innovative designs by students that are inspiring to students and adults alike. They can also lead to other great videos.

Makosinski, A.(2014). Can I power a flashlight without batteries? Retrieved 6/11, 2016, from

<https://www.youtube.com/watch?v=yrrNmzSSn0w>

Singh, K. (2014). 9 incredible science projects by brilliant kids. Retrieved 6/11, 2016 from <http://mashable.com/2014/08/26/science-projects-kids/#tzTE9.UXqGqx>

Taylor, A. (2014). 1964: the new york world's fair. Retrieved 6/11, 2016, from <http://www.theatlantic.com/photo/2014/06/1964-the-new-york-worlds-fair/100749/>

YouTube. (2013). 2013 young scientist challenge winner: Peyton Robertson. Retrieved 6/11, 2016, from

<https://www.youtube.com/watch?v=TWTEceGEyYU>

YouTube. (2014). Hot Car Safety System. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=jx4E5CHL50E>

Youtube. (2014). iGlasses HD. Retrieved 6/11, 2016, from <https://www.youtube.com/watch?v=nSJ8BN5SSHU>

Science Kids. (2016). Engineering videos. Retrieved 04/05, 2016 from

<http://www.sciencekids.co.nz/videos/engineering/bridgebuilding.html>

Resources

Background picture. Retrieved 08/03, 2016, from

https://www.google.com/imgres?imgurl=https%3A%2F%2Fpixabay.com%2Fstatic%2Fuploads%2Fphoto%2F2016%2F04%2F18%2F14%2F06%2Fbackground-1336511_960_720.jpg&imgrefurl=https%3A%2F%2Fpixabay.com%2Fen%2Fphotos%2Fmechanical%2520engineering%2F&docid=U7DcZLw5n3KtnM&tbnid=dFkBk3F3IS6QkM%3A&w=960&h=678&hl=en&bih=643&biw=1366&ved=0ahUKEwikN3K66fOAhUDRSYKHdGoAwsQMwiBASglMCU&iact=mrc&uact=8 B

Gears picture. Retrieved 08/03, 2016, from

https://www.google.com/imgres?imgurl=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fthumb%2F4%2F46%2FRed_Silhouette_-_Gears.svg%2F2000px-Red_Silhouette_-_Gears.svg.png&imgrefurl=http%3A%2F%2Fcommons.wikimedia.org%2Fwiki%2FFile%3ARed_Silhouette_-_Gears.svg&docid=aolArzLgzNGVHM&tbnid=pK3TMOixO6CljM%3A&w=2000&h=2000&hl=en&bih=643&biw=1366&ved=0ahUKEwiHoueDnajOAhXESSYKHRcsCoEQMwhaKB8wHw&iact=mrc&uact=8