

Reverse Engineering
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Fifth Grade
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Interactions affect Systems

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I. Introduction

Concept Lens: Interactions
Essential Understanding: Interaction affects systems



Rationale

As students advance through fifth grade, they are introduced to various systems, migration within a system, economic systems, human body systems, weather systems and ecosystems. Their understanding of how they interact in each system deepens their understanding of impact and influence. The influence must be enticing enough, strong enough or simple enough to pave a way for an interaction to occur. It depends on the need or desired outcome. Interactions influence human behavior, academic knowledge, creativity and ingenuity within a system.

In order for students to develop an understanding of a system, develop an appreciation or make an impact on the system, they must acquire knowledge of the systems' parts and investigate how the parts interact. During the investigation, they must document their findings so they can put the system back together to its original form, improve the system, or change the outcome of the system.

Students must have experience interacting with several different systems to understand there is a process in their investigation. They will ask why are they interacting with the system, imagine the changes they want to make, create a plan and improve the system or keep it restore it to its original form. Students will communicate why the change is necessary or unnecessary.

Population and Differentiation for Gifted Learners

Population

This is a unit of study that focuses on the content area, reverse engineering, and the essential understanding of how interactions affect systems. The unit of study is suited for academically and intelligently gifted students in fifth grade or higher. The academic content is not a prerequisite for the class, but the transfer of concepts and content is better suited for this age group because of their experiences with other systems and force and motion. The content, process skills, guiding questions that lead to the essential understanding and the planned learning experiences are tailored for the AIG student.

Process Skills with Depth and Complexity

The reverse engineering unit is designed for gifted students to investigate various toy systems. The progress skills are designed to challenge the gifted student. Students make evaluations about changes, evaluate the ethics of changing a system, analyze the systems' parts and interaction of parts, apply knowledge to another system, create a system of inquiry and analyze information to make generalizations. Students engage in in-depth critical thinking as they analyze how parts

interact in a system, group the parts based on similarities and differences and then regroup them again. This process deepens the understanding of the concept, interaction.

The method of creative problem solving analyzes data and relevant information, synthesizes solutions and possible outcomes and applies reasoning to support conclusions. Students create new ideas through divergent thinking, make judgments about their ideas and select ideas based on convergent thinking. They evaluate the purpose of creative problem solving and apply the process to other authentic situations.

Content with Depth and Complexity

Big ideas are used to add depth and to make generalizations about the information. Students read high-level content about toy systems, and how changes and interactions evolve over time. The content focuses on the changes within the system over time and language within the discipline that experts use to understand the system.

Students will read, discuss and identify information to make generalizations about reverse engineering by reading a high-interest book about Steve Jobs. Students further their depth of new knowledge by researching the toy and details of the components. Students make decisions about improving the system based on their research and their own interaction with the system.

Learning Environment with Depth and Complexity

Students work together in collaborative groups to problem solve or they may work alone.

Students share ideas and work in a small group setting to create a product.

Students partner read or read alone.

Students are organized into similar interests for performance task.

Product with Depth and Complexity

Lesson 1: Students create a poster to show their understanding the process of reverse engineering.

Students give feedback to their peers.

Exit tickets ponder the questions, “How do interactions affect a system and how do systems affect interactions?”

Lesson 2: Students share generalizations on exit tickets. “What generalizations can they make about the parts and the system? The students consider why this important to observe and analyze how interactions affect a system in reverse engineering.

Lesson 3: Students create a new product or solution for their broken toy. This is creating a new product that synthesizes the meaning of the concepts, creative problem solving and how interactions affect systems.

Students create an acronym to reflect the process of creative problem solving.

Lesson 4: Students work in teams or individually on an authentic performance task. Students create a new toy, a plan to create the toy and a way to advertise the toy. Each group must work collaboratively to problem solve and create a new product.

Lesson Pacing

Lesson 1- Bruner Model lesson requires two days of 90-minute time blocks.

1. The first day will consist of reading about a scientist, viewing videos about reverse engineers, understanding what reverse engineers do and how they interact with a system and making generalizations about how interactions affect systems. The performance task is introduced on this day and the rubric. Time needs to be allowed for students to visualize what their project may look like and reflect on their task of being a scientist that studies reverse engineering.
2. The second day will consist of creating a visual representation to reflect on their understanding of the reverse engineering process and getting feedback from their peers. Time is allotted for the performance task. Students need time to interact and plan with their peers, reflect on the concept and apply their new ideas to the performance task.

Lesson 2 – Taba Lesson requires two 90-minute time blocks.

1. The first day of this lesson will consist of students reading and exploring an informational text about the ways toys work. In this lesson, students will disassemble toys and analyze their parts.
2. The second day will consist of going through the steps of a Taba lesson with listing, grouping, labeling, regrouping and renaming the similarities the students have encountered with interactive parts in a system. Exit tickets will be completed to show understanding of the essential understanding. Time for the performance task is allotted during this lesson to reflect and define their perspective on how the task will be completed.

Lesson 3 - Creative Problem Solving requires two 90-minute time blocks.

1. The first day, students will encounter the mess they have recreated from lesson 2. They have broken toys, disassembled toys and toys that need improving or repairing. Stages 1 – 4, Mess Finding, Data Finding/Fact Finding, Problem Finding Within a System and More Problem Finding, of Creative Problem Solving will be completed.
2. The second day, students will complete stages 5 – 8, Idea Finding, Solution Finding, More Solution Finding and Plan of Action. Acronym group projects are assigned. Time is allowed to reflect on task performance.

Lesson 4 – Questioning Model requires one 60-minute time block and one 120-minute time block.

1. The first day, students will watch videos on the history of roller coasters and explore how systems interact with other systems and changes occur over time.
2. The second day, students will work on the performance task, receive feedback from their peers and share projects.

II. Goals and Outcomes



The following are content, process and concept goals for this unit. Selected goals are aligned with North Carolina Standards.

Content Goals and Outcomes

Goal 1: To understand the interactions of matter and energy and the changes that occurs.

Students will be able to...

- A. Examine components in a system and how they interact to produce interactions and changes.
- B. Examine the role of reverse engineers and why they interact with the system, the energy produce and make changes.
- C. Describe how interacting with a system creates new ideas for changes.
- D. Compare and contrast kinetic energy and potential energy in systems.
- E. Analyze how an interaction occurs in a system there may be change in state or form.

Goal 2: To understand force, motion and the relationship between them.

Students will be able to...

- A. Analyze different types of movements within a system
- B. Analyze mechanisms in systems and define movements.
- C. Examine a simple machine for altering force or motion.
- D. Analyze how energy is the ability to do work.
- E. Analyze how when work occurs there is a change in position and/or speed

Process Goals and Outcomes

Goal 1: To analyze information with application to science.

Students will be able to...

- A. Analyze information to make generalizations about roles of reverse engineers.
- B. Analyze linear, reciprocating, oscillating and rotary movements.
- C. Analyze content to make connections to a system.
- D. Collect and analyze data and relevant information including alternate approaches.

Goal 2: To develop evaluation skills with application to science.

Students will be able to...

- A. Evaluate the purpose of a system and interactions within a system.
- B. Evaluate the idea of ethics and honoring others' ideas and products.
- C. Critically evaluate the process of creative problem solving through divergent thinking skills and convergent thinking skills.

- D. Judge and select statements based on convergent thinking.
- E. Make judgments about a new system.

Concept Goals and Outcomes

Goal 1: To understand the concept of systems

Students will be able to...

- A. Evaluate the purpose of a system
- B. Evaluate how the system affects the interactions.
- C. Recognize the value of understanding the system and the process of reverse engineering.
- D. Modify the parts of a system to improve the system.
- E. Create a new system.
- F. Create a plan to show the mechanisms of the system.
- G. Compare and contrast the new system to the old system.

Goal 2: To understand the concept of interactions

Students will be able to...

- A. Evaluate the purpose of an interaction.
- B. Evaluate how the interaction affects the system.
- C. Analyze data and information to interact with a system through exploded views and patent information.
- D. Modify the parts of a system to create new interactions.

III. Assessment Plan



Formative Assessments

Students will be assessed throughout the unit formally and informally. Observations will be made during discussions, independent work and collaborative work sessions. Formative assessments will consist of exit tickets and group projects.

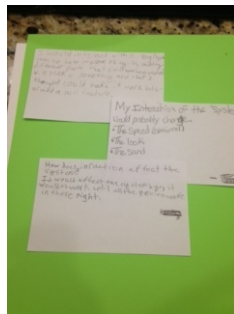
1. Exit Tickets- Exit tickets are given to gather information and to do a quick assessment of the students' understanding of the concept and content knowledge. Exit tickets assist in determining how to proceed with instruction.

The exit tickets are sorted into three categories that represent student understanding.

Category 3: Students who grasp the content and concept.

Category 2: Students have a basic understanding of the content and concept.

Category 1: Students who do not understand the content and concept.



Posed questions for exit tickets.

Day 1: How does an interaction affect a system? How is a system affected by an interaction?

Day 2: What generalizations can you make about the parts of a system and the system?

2. Group Projects- Group Projects are assigned to gain understanding of content knowledge, unit concept and the skill development. Students review and give feedback on their peers' projects. They are assessing their peers on accuracy and evidence of the process and understanding of content knowledge and unit concept.

Day 1: Groups create a poster to guide them in understanding the steps in the process of reverse engineering.

Day 3: Groups create an acronym for creative problem solving process.

How would this word help others remember the process to make creative decisions? How would this acronym encourage reverse engineers to creatively solve problems?

How would the acronym represent how reverse engineers interact with systems to solve problems?

Formative Assessment Rubric for Exit Tickets

Score:	Explanation for score:
3 = Excellent	Thorough, complete and original ideas are explored in detail throughout the entire assignment. New theories are presented about the concept and content.
2 = Satisfactory	Substantial ideas are expressed, but other ideas are recycled about the concept and content.
1 = Unsatisfactory	Incomplete ideas are expressed. There is a misunderstanding of concepts and content.

Formative Assessment Rubric for Projects

Score:	Explanation for score:
3 = Excellent	Highly effective ideas are explored in detail throughout the entire project. Exceptionally clear theories are presented about the concept, content and process skills. Easy to understand.
2 = Satisfactory	Generally effective ideas are expressed throughout the project. Generally clear ideas are presented about the concept, content and process skills. Able to follow.
1 = Unsatisfactory	Somewhat effective ideas are expressed. The ideas lack clarity about the concept, content and process skills. Difficult to follow and understand.

3. Teacher observations will assess the understanding of the content knowledge, unit concept and skill development. Students have the opportunity to share their perspectives, interpretations and analyses in small groups and in pairs about how interactions affect systems.

Summative Assessment

The Toy Fair – Performance Task

You are a product designer in demanding world of toy design. Your application to debut your newly designed toy at the 2016 Toy Fair in New York City has just been accepted. Your design team is working around the clock for the debut. Retro will be all the rage at the Toy Fair. It is a new toy category that highlights veteran toys with new updates that will appeal to today's curious minds.

There will be an abundance of manufacturers there to land a deal with your design team to produce your reengineered toy. They will be there ready to produce the next in-demand toy that will have children pulling at their parent's pants leg to purchase.

Because your team understands your toy system and the toy interactions, your team will need to create a design plan for manufacturers at the trade show to follow and understand so they can reproduce the toy. The plan involves documenting the parts of the toy and how they work together. Along with the design plan, you will need to know how to promote the toy and target the audience your toy will appeal to and offer endless hours of amusement.

Your design team will allow another toy product designer group in our class to take a sneak peek at your newly designed toy. They will give you written feedback before you make your grand debut at the Toy Fair. Make sure you have the following ready for your peers' sneak peek.

- **A diagram of the toy parts-** so the manufacturer knows the inside details of the system
- **A promotion poster or visual for the toy** – so the manufacturer knows the targeted audience; how and why someone interacts with the new system; how does the visual affect someone's perspective of the new system
- **The newly designed toy-** the new system

The feedback your peers provide you will be completed on the Performance Task Rubric.

Analytic Rubric
Understanding: Interactions affect Systems
Task Performance

Category	4 Excellent	3 Good	2 Satisfactory	1 Unsatisfactory
Conceptual Understanding	Student demonstrates a thorough and complete understanding of how interactions affect systems in the new toy.	Student demonstrates substantial understanding about how interactions affect systems in the new toy	Student demonstrates a partial or incomplete understanding of how interactions affect systems in the new toy	Student demonstrates a lack of understanding of how interactions affect systems. There are misunderstandings in the new toy.
Content Knowledge	Student demonstrates thorough and complete understanding of reverse engineering in the design plan.	Student demonstrates substantial understanding of reverse engineering in the design plan.	Student demonstrates partial or incomplete understanding of reverse engineering in the design plan	Student demonstrates a lack of understanding of reverse engineering. There are misunderstandings in the design plan.
Organization and Presentation	Student's work and information is presented creative and well-organized manner. Ideas are exceptionally clear in the promotional visual.	Student's work and information is presented in an organized manner. Ideas are generally clear in the promotional visual.	Student's work and information is inconsistent and difficult to understand. Ideas lack clarity in the promotional visual.	Student's work and information lacks organization and effort. Ideas are unclear in the promotional visual.
Participation and Contribution	Student always interacted with group members, supported group members, showed leadership in completing the task.	Student generally interacted with group members and participated in task.	Student sometimes struggled with interacting with group members and following directions.	Student rarely or never interacted with group members and offered minimal support.

Total score ____ / 16

TEACHER NAME		Lesson #
Kelly Nuckols		Camp lesson #1
MODEL	CONTENT AREA	GRADE LEVEL
Bruner	Science	5
CONCEPTUAL LENS		LESSON TOPIC
Interactions		Reverse Engineers
LEARNING OBJECTIVES <i>(from State/Local Curriculum)</i>		
Describe reverse engineering as process of disassembly and careful analysis with the goal of duplicating or improving a device or component. Describe the process of reverse engineering Understand the goals of reverse engineering Understand parts of a system that generate different movements. 5.P.2 Understand the interactions of matter and energy and the changes that occur.		
THE ESSENTIAL UNDERSTANDING <i>(What is the overarching idea students will understand as a result of this lesson?)</i>		THE ESSENTIAL QUESTION <i>(What question will be asked to lead students to “uncover” the Essential Understanding)</i>
Interactions affect systems		<i>How do interactions affect systems?</i>
CONTENT KNOWLEDGE <i>(What factual information will students learn in this lesson?)</i>		PROCESS SKILLS <i>(What will students be able to do as a result of this lesson?)</i>
Students will know... That engineering is the work of designing and creating structures, systems or new products by using scientific methods. That a system is a group of related or connected parts that move or work together. That reverse engineering is a process. (Reverse engineering is the process of disassembly and analyzing the product back to its original design or to improve the design. There are 5 steps: ask, imagine, plan, create and improve) There are different types of movements: linear, reciprocating, oscillating, rotary. (Linear – moving in a straight line; reciprocating – moving backwards and forwards; oscillating – swing from side to side; rotary – turning in a circle) Know an interaction is when two or more people or things communicate with or react to each other. Know that interacting with a system creates new ideas. Know engineers must honor others ideas and understand ethical issues when creating products Know a generalization is a taking a few facts and making a broad statement or idea that apply to a group of people or things. Generalizations are not entirely true.		Students will be able to... Evaluate the purpose of a system and interactions within a system. Observe and analyze information to make generalizations. Evaluate the idea of ethics and honoring others’ ideas and products. Apply information to create a system of inquiry. Observe and analyze system interactions. Analyze toys moving in linear interactions or interactions in a straight line. Analyze toys moving backwards and forwards or in a reciprocating motion. Analyze toys swinging side to side or in an oscillating interaction. Analyze toys making rotary interactions or turning in circles.

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 are interactions? What is a system? How do systems operate? How do systems interact with other systems? What systems do reverse engineers interact? What do people who practice reverse engineering do? Where might interactions with reverse engineering take place? What are ways engineer gather information, understand the information and interact with the information? What tools are used to interact with a system or structure? Why would engineers interact with a system? How could engineers interact with understanding a system?	What did reverse engineers do and learn from the systems in each video? How did they perform their tasks? What was the purpose for interacting with each system? How do the engineers interact with each other? How did they gather information and understand each system? What methods did you observe in the interaction process? How different are the interactions with the individual systems in each video?	How did your group go about interacting and understanding the toys? What was your process in understanding the system and understanding the toy interactions? How did the toy interact with the environment? How would you document the information you learned and observed about the toys? How would you change or improve the toy system? How does your interaction affect a system?	
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
	Students will discuss and identify information to make generalizations about reverse engineering by using high level content.		The ideas for the posters are student driven. What process would a real life engineer follow to understand a system?

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.

"Have you ever just wanted to take a toy apart to see what makes it tick, tock, rock, roll or move? Plus, put it back together again or change it? You have experienced a desire to be a reverse engineer! First of all, we need to understand an engineer's job. What did they do? So, does a reverse engineer walk backwards? No, what might reverse engineers do?"

Have disassembled toys on display. Students will record their theories about how engineers who specialize in reverse engineering interact with systems.

Students will read Who Was Steve Jobs? (with exception to Ch. 4)

1. Give students a journal to record their ideas.
2. Students will independently list what they think is involved in reverse engineering.
3. Students should consider:
 - What do engineers do in reverse engineering?
 - What tools do engineers use?
 - Where might engineers work?
 - Why would engineers want to interact with the process of reverse engineering?
 - What characteristics do engineers possess that are interested in reverse engineering?
4. After 5 minutes of listing, students share their thoughts with the class. The teacher will record responses so the class can see them.
5. The teacher asks "Pre-lesson Questions". As a whole group, students share their responses.

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.

1. Teacher shows videos. (Pause after each video and let students record thoughts.)
 - a. History Channel UFO Hunters 107 Reverse Engineering www.youtube.com/watch?v=INgY7UtxLSs
Teacher note: This video highlights an interesting idea of UFO. Discuss with the class it may be a hoax. It shows a team of engineers working together studying aircraft. They imagine possibilities and recreate an aircraft. They interact with each other, technology and the aircraft. There is an issue of ethics. The engineers use various disciplines such as physics and geometry.

Vocabulary pertinent to the video – not pertinent to the lesson

- Freedom of Information (FOIA) - The law that gives you the right to access information from the federal government. It is often described as the law that keeps citizens in the know about their government.
- drone- an unmanned aircraft or ship that can navigate autonomously, without human control or beyond line of sight;
(loosely) any unmanned aircraft or ship that is guided remotely
- physics- the natural science that involves the study of matter and its motion through space and time along with related concepts such as energy and force

- b. Strawbees - Kickstarter www.kickstarter.com/projects/1624049406/strawbees-dream-big-build-bigger

Teacher note: This is playful video about inventing a new item and recreating ways to interact with other items. The team demonstrates different movements the simple strawbee can generate.

- c. "Taking Stuff Apart" www.youtube.com/watch?v=YvZ3-JRKXuQ

Teacher note: This high-energy video of a regular man taking apart a microwave. He inquires about the parts and organizes the parts.

2. While viewing the videos, the students focus on how the engineers interact with each system.
3. Students look back at their list they created in the Explore stage. What additions would they make based on the videos?
4. Ask the “During the Lesson” questions.
5. Students are divided into groups of 3. Their role is to be a team of engineers studying reverse engineering on toys and the toys’ purpose. Students will study and interact with the toys, and the way the toy interacts with the environment. The teacher will preselect toys based on the toy movements. (linear, rotating, oscillating, reciprocating) Numerically label each group of toys.
6. Students will record in their journals observations about the toys and how the toys interact with the environment.
7. Students will rotate from toy group to toy group.
8. Students should keep notes about the interactions that were involved in each toy group.
9. The groups of students will share and interact with each other about their observations and make generalizations about the way the toys interact with the environment before they go to the next toy group. Discuss the definition of generalization.
10. Students should consider:
 - What did you observe?
 - What does your observation tell you about the toy?
 - What did your observation tell you about the toys movement and the way it interacted with the environment?
 - How can you use your combined observations to make a generalization about each group of toys?

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.*

1. After students have completed all of the stations, the class will discuss the process each group went through to make a generalization about the toy groups.
2. Ask “Post Lesson Questions”
3. Students share orally their thoughts. Discuss the process they came up with understanding each toy grouping. How did they make the generalization based on their understanding of each toy group?
4. Further discuss different toy movements by using information from <https://www.londoneye.com/LearningAndDiscovery/Education/TeacherResource/OnlineResource/mechnism/mechtea.pdf>
5. Have students do an investigation on the types of movement. (Types of Movement Investigation Sort)
6. How does understanding the toy movements deepen their understanding of each toy group?
7. How does it affect the way you interact with that system?

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*

1. Regroup the students.
2. The goal for this part of the lesson is for the students to reflect on what they did to understand each toy group or system. What steps would an engineer go through to study a system to improve it or put it back together?
3. Think about the role of an engineer. How does his/her interaction impact the system? What is his/her impact on the system?
4. Have them create a poster that a real life engineer would use to understand the reverse engineering process for any toy system. The students should reference their notes and generalizations. What did they do when they interacted with each toy group to understand the system?

Teacher notes:

Encourage each group to interact with each other on the process of understanding a system.

- *the purpose, problem or goal of the toy or system*

- *imagine movements or toy interactions*
- *materials, diagrams, plans*
- *improvements*

That reverse engineering is a process. Reverse engineering is the process of disassembly and analyzing the product back to its original design or to improve the design. There are 5 steps: ask, imagine, plan, create and improve.

In this lesson, students were involved in the first two stages of the process:

- *ask - determine the original design goal*
- *imagine - observe the original product in action*

4. Display posters. Have students present their posters to the class.

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

Formative assessment: Have students view each poster and make comments on the other groups' posters. Students write their comments on post-it notes and place them on the posters. Teacher views posters and comments.

Closure: Upon leaving, have students ponder the following statements.
How does interaction affect a system? How is a system affected by an interaction?

Day 1- Types of Movement Investigation Sort

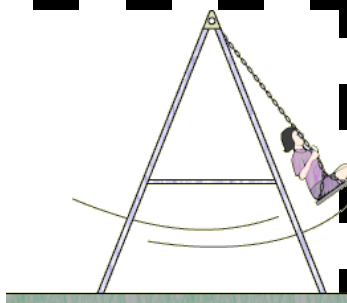
Place the definition cards and example cards beneath each type of movement.

ROTARY	OSCILLATING	LINEAR	RECIPROCATING

moving backwards
and forwards in a
straight line



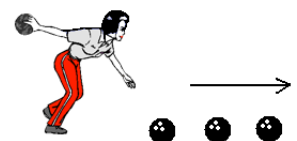
turning round in a circle



is moving in a straight
line



swinging from side to
side



TEACHER NAME		Lesson #
Kelly Nuckols		Camp lesson 2
MODEL	CONTENT AREA	GRADE LEVEL
Taba	Science	5
CONCEPTUAL LENS		LESSON TOPIC
Interaction		Reverse Engineer
LEARNING OBJECTIVES <i>(from State/Local Curriculum)</i>		

5.P.2 Understand the interactions of matter and energy and the changes that occur. Describe the key mechanical components and how they function in a system. Describe reverse engineering as process of disassembly and careful analysis with the goal of duplicating or improving a device or component.		
THE ESSENTIAL UNDERSTANDING <i>(What is the overarching idea students will understand as a result of this lesson?)</i>		THE ESSENTIAL QUESTION <i>(What question will be asked to lead students to “uncover” the Essential Understanding)</i>
Interactions affect systems		How can an interaction affect a system?
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... An autopsy is an analysis of something after it has been done or made. An analysis is separation of a whole into its component parts An analysis of parts is a part of the reverse engineering process A system is a group of related parts that move or work together. A simple machine is a simple device for altering the magnitude or direction of a force. An exploded view drawing shows how an object is assembled. Mechanisms in systems define movements. Gears are responsible for turning movements. Levers consist of a beam, a stick, or a rod that are used for a platform and is balanced over a fixed pivot point. Pulleys are grooved wheels with a rope and they are used to lift heavy objects. A cam is a rotating or sliding piece.		Students will ... Analyze the parts in a system. Analyze the way parts interact and affect a system. Analyze content to make connections to a system. Make generalizations about how parts interact in a system and affect the system. Apply understanding of reverse engineering process. Evaluate the importance of understanding a system in reverse engineering. Work collaboratively in small groups.
GUIDING QUESTIONS <i>What questions will be asked to support instruction?</i> <i>Include both “lesson plan level” questions as well as questions designed to guide students to the essential understanding</i>		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
How would you justify this video as being a part of the process in reverse engineering? What purposes would there be in performing an autopsy on a toy? How would this help you understand interactions within a system?	What interactive parts do you see in the toy? Why did you group them that way? How would you label the groups you formed? What are the similarities and differences between the interactive parts in the systems?	What do you think the next step would be after you take a toy or system apart? How does using an exploded view drawing assist in the process and the concept of interactions and systems? What is the relationship between the parts and their movements?

Who would benefit from taking a toy apart and why? How does understanding the inside help you understand the entire toy system?	How are the parts interacting with each other? What is the effect of the parts interacting with each other?	When would you take a system apart? How does understanding the parts of a system help you understand the parts' interaction? How does understanding the parts and the way they interact help you better understand the system? As a reverse engineer, why would you interact with system?
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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
	Students engage in in-depth critical thinking as they analysis how parts interact in a system. Students will do this by analyzing the mechanisms in the toy and group the mechanisms' similarities and differences, and then, regroup them again. This process helps student deepen their understanding of the concept, Interaction.		

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.

"Yesterday, we observed the way toys move and interact with the environment. We know toys can move in a linear motion, a rotary movement, an oscillating motion and a reciprocating and possibly, a combination of any of the movements. Today, we are going to watch a video of an autopsy of a Furby. How would a reverse engineer find this video interesting?"

<https://vimeo.com/90741916>

Ask the pre-lesson questions and write the responses on the board.

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.

Students will read excerpts from *The Way Toys Work*. This is an informational text that explores interactive parts of a system and the concepts of toy interaction and systems. These readings are to get the students thinking about the way some toys command interest and wonder. They do the unexpected or the impossible. They make us think. How do they work? How do they interact? How do they relate to science ideas we have learned? How do we interact with the system?

Sobey, E., & Sobey, W. (2008). *The Ways Toys Work*. Chicago, IL: Chicago Review Press

Students will read "Furby", "Push 'N' Go Car", "Yo-Yo", "Wind-Up Toy" and "Helicopters" from *The Way Toys Work* - (There is an exploded view drawing of each toy that show how an object is assembled. The parts are shown as a part of the system and how they go together to interact in the system. The mechanisms, cam, gears, lever, pulleys, are labeled in the exploded view drawing.)

The goal is for students to think about these toys experience interactions within a system and how an interaction affects a system. In the next part of the lesson, the children will have a hands-on approach to interacting with a system. They will explore the concept of how interactions affect systems.

Listing Stage:

Group student is a group of 3 or 4. Give them a set of toys. The students will analyze and disassemble the toys. What do they observe about the toy parts and the interactions? Students will list examples of interactions they observe with the system. Encourage the students to construct various, but specific list of the parts. Use specific vocabulary like cam, gears, levers.

Rules for listing: Make a list of at least 20 specific items

Students will share their lists and the teacher will post responses on the board.

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.

Grouping and Labeling

1. How do the students see similarities in the way the parts are interacting? Students should group items from the previous list based on the similarities of the interaction.
2. Groups of student will work together in order to decide which items in the list go together because they are alike in some aspect of the interaction.
3. Students will be provided with the following rules: at least three different groups, at least three items in each, cannot use any item twice.
4. The teacher will move throughout the classroom checking in with student groups. The teacher will guide students as necessary with questions but allow the student groups to come to their own conclusions. As students finish, the teacher will instruct student to label the newly defined groups.

5. Students will explain their reason to the teacher. The teacher will ask students to describe the similarities and differences among groups.

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

Regrouping, Renaming

1. Student groups will be challenged to regroup the items with new labels. Rules: Students must regroup items and give new groups new labels. The groups will be based on similarities in the interactions.
2. The teacher will ask all groups to share their new categories.

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

The teacher will end the lesson by asking the class to explain how an interaction between the parts of a system effect the whole system.. Students will be expected to record their thoughts on an exit ticket. What generalizations can they make about how interactions effect the whole system? The students should consider why this is important to observe and analysis how interaction affects a system in reverse engineering. Students will submit their thoughts on the exit ticket. Students will be assessed throughout the lesson during small groups and full class discussions. Students will submit their exit tickets to the teacher.

TEACHER NAME		Lesson #
Kelly Nuckols		Camp lesson 3
MODEL	CONTENT AREA	GRADE LEVEL
Creative Problem Solving	Science	5th grade
CONCEPTUAL LENS		LESSON TOPIC
Interactions The Essential Understanding Interactions affects system.		Reverse Engineering The Essential Question How do interactions affect systems?
LEARNING OBJECTIVES <i>(from State/Local Curriculum)</i>		
5.P.1 Understand force, motion and the relationship between them. 5.P. 2 Understand the interactions of matter and energy and the changes that occur. 5L5.1a Engage effectively in a range of collaborative discussions with diverse partners on grade 5 topics and building on others' ideas and expressing their own clearly. SL 5.1c Pose and respond to specific questions be making comments that contribute to the discussion and elaborate on the remarks of others		
THE ESSENTIAL UNDERSTANDING <i>(What is the overarching idea students will understand as a result of this lesson?)</i>		THE ESSENTIAL QUESTION <i>(What question will be asked to lead students to "uncover" the Essential Understanding)</i>
<i>Interactions affect systems.</i>		<i>How does interaction affect systems?</i>
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... Divergent thinking is tending to be different or moving away from what is expected. Convergent thinking is coming closer together or moving to one point. Reverse engineering is a process. (Reverse engineering is the process of disassemble and analyzing the product back to its original design or to improve the design. There are 5 steps: ask, imagine, plan, create and improve) Energy is the ability to do work. Work occurs when there is a change in position, speed, sate or form. Potential energy is stored energy and exists when something is at rest. Kinetic energy is energy being used. A force must act upon the object for the energy to make a move.		Students will.... Analyze strategies for problem solving skills. Collect and analyze data and relevant information including alternate approaches. Synthesize solutions and possible outcomes. Apply reasoning to support conclusions. Create new ideas through divergent thinking. Judge and select statements based on convergent thinking. Evaluate the purpose of creative problem solving. Work collaboratively in small groups throughout the creative problem solving process

GUIDING QUESTIONS <i>What questions will be asked to support instruction?</i> <i>Include both "lesson plan level" questions as well as questions designed to guide students to the essential understanding</i>		
Pre-Lesson Questions:	During Lesson Questions:	Post Lesson Questions:
<i>When you have a broken system, when should the system be put back to its original design?</i> <i>What happens when you are not getting the results or the reactions you want from the system?</i> <i>What do you base your decisions on to change the system to get different or better results?</i> <i>When should the parts change in the system to get the desired interactions?</i> <i>How can you implement the best decisions in the reverse engineering process?</i>	<i>Mess Finding</i> <i>What should be the goal your group wishes to achieve by doing something about the mess of disassembled toys?</i> <i>What do you stand to lose by not interacting with the mess or we did not interact with the mess?</i> <i>What good is coming from the current situation?</i> <i>How can we interact with this mess so it is not a mess?</i> <i>What is the goal of interacting with the mess?</i> <i>Fact/Data Finding</i> <i>Who is involved in interacting with the mess?</i> <i>What is involved in interacting with the mess?</i> <i>What connections and can you make with the mess?</i> <i>What are some examples of the problem?</i> <i>What caused the problem, the mess?</i> <i>Where do problems like this occur?</i> <i>How does the mess happen in systems?</i> <i>Are there any more problems caused by interacting with systems?</i> <i>Problem Finding</i> <i>What is the real problem?</i> <i>How do we know if any systems are in the mess?</i> <i>What is the objective?</i>	<i>Why would creative problem solving be a part of reverse engineering?</i> <i>Why is interacting with others are a part of creative problem solving?</i> <i>How can understanding the goal of a system be a part of creative problem solving?</i> <i>How did you interact in each stage?</i> <i>How does the system of creative problem solving support the reverse engineering process?</i> <i>How did you interact with each other to obtain your goals in creative problem solving?</i> <i>How can you ensure the best solution will be implemented in creative problem solving?</i> <i>How do interactions affect systems?</i> <i>How do systems affect interactions?</i>

	<i>What do we want to accomplish?</i> <i>What are our concerns?</i> <i>What is our challenge?</i> <i>What wish would we like to fulfill?</i> <i>Acceptance Finding</i> <i>How might I gain the other engineers acceptance in the class?</i> <i>What resources are needed to implement our idea?</i> <i>How might we overcome any obstacles?</i> <i>What might go wrong?</i> <i>What might go wrong in a system?</i> <i>What can we do to prevent problems?</i> <i>What opportunities might be presented?</i> <i>What should we not do?</i> <i>When should we not follow a plan because an interaction affects a system?</i> <i>As engineers practicing reverse, engineering, how might we best gain support for our ideas from the class?</i>		
DIFFERENTIATION <i>(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.</i>			
Content	Process	Product	Learning Environment
	Students collect information in response to a challenge; Analyze and draw conclusions from statements, data and other evidence; Assess the implications and consequences of their conclusions.	Create a new product that synthesizes the meaning of the concepts, creative problem solving and interaction affects systems.	

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.

The Mess

Stage each work area with a pile of broken toys and the disassembled toys the children have been interacting with for the week in view for them. Label it with a sign called "Mess".

Say, "Engineers, this is the mess we have created this week. We have a lot of broken toys. Let's talk about this week. On the first day, we looked at what engineers do in reverse engineering, what they know and what they believe and qualities of an engineer in this discipline. You created posters that reflect your understanding of the reverse engineering process. Review their posters.

On our second day, we looked at the concept of reverse engineering. What ideas, what theories are explored in reverse engineering by interacting with systems?

When we combine the 2 lessons – We understand how interactions affect a system. Reverse engineers interact within systems like in a toy system. Why would they interact in a toy system?

Questions to prompt interactions:

When you have a broken system, when should the system be put back to its original design?

What happens when you are not getting the results or the reactions you want from the system?

What do you base your decisions on to change the system to get different or better results?

When should the parts change in the system to get the desired interactions?

How can you implement the best decisions in the reverse engineering process?

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.

Tell the engineers they are going to deal with "The Mess" by creative problem solving as engineers putting reverse engineering into practice. They will work in small groups. There are some guidelines they need to be aware of before they go into the creative problem-solving mode.

Brainstorming Guidelines:

- Far out ideas are welcome – Freewheeling is welcome.
- All ideas are acceptable.
- No criticism
- Spin off ideas are welcome
- To stimulate thinking – think of substitutions, combinations, modifications magnify, minify, put to other uses, eliminations, reverse

The groups will need to have the Creative Problem Solving graphic organizer. This will be done in stages.

Stage 1- Mess Finding

State the situation: **"The first step is take action about the pile of dissembled toys and broken toys What should be the goal your group wishes to achieve by doing something about the mess of disassembled toys?"**

What has happened? Or, what has not happened. Write you concerns thoughts and the changes you like to see happen with this mess. Let your thoughts flow. "

- For 2 minutes, write your concerns, thoughts and the changes you would like to see in this situation on the graphic organizer.
- Someone from the group will be the scribe and write the concerns, thoughts and the changes for the

group.

- Next, describe the situation in a 3 – sentence overview.
- Questions to help with the flow of ideas and think about how interactions affect systems:
 - What would you lose if something was not done about the mess or we did not interact with the mess?
 - What needs to be improved?
 - What good is coming from the current situation?
 - How can we interact with this mess so it is not a mess?
 - What is the goal of interacting with the mess?
- Now, summarize and restate the problem using a “How to ...” statement.

Stage 2 – Data Finding/Fact Finding

Data finding is an effort to identify all known facts related to the situation, to look and identify information that is not known but essential to the situation. The goal is to have all the knowledge pertinent to the situation so the children can identify and define the key problem and how reverse engineers would handle the problem.

- “List all the key facts associated with your situation or your desired outcome as your group perceives them. Ask yourself some really important questions like.

Questions to help discover facts.

- How is the mess like a system?
- What are the interactions?
- Who is involved in interacting the mess?
- What is involved in interacting with the mess?
- What connections can you make with the mess?
- What are some examples of the problem?
- What caused the problem, the mess?
- Where do problems like this occur?
- How does it happen in systems?
- Are there any more problems caused by interacting with systems?
- “Then ask questions pertaining to what **additional facts** you would like to know and where you might search for them. Your goal is to have all the knowledge pertinent to the situation so that you can identify and define the key problems.”
- “Use DIVERGENT THINKING to brainstorm all the known facts. List the known facts on the graphic organizer under ‘Data Finding’.”
Guidelines for Effective Divergent Thinking
 - Defer judgment.
 - Accept all ideas
 - Make yourself STRETCH for ideas
 - Take time to let ideas simmer
 - Seek combinations – be a hitchhiker
- “What facts are lacking? List them on the graphic organizer.”
- “Now, apply CONVERGENT THINKING to judge and select the most important facts. Circle the most significant fact and those that provide a key to your situation.”
Guidelines for Effective Convergent Thinking:

- Be Deliberate
- Be explicit
- Avoid premature closure
- Look for sneaky spots
- Develop affirmative judgment
- Don't lose sight of your goals.

Stage 3: Problem Finding Within a System

This stage is an effort to identify all the possible problem statements and then to isolate the most important or underlying problem.

- “Considering the data you have gathered about your situation during Fact Finding, determine what you want to accomplish in more specific terms. Ask yourself the following questions.”
What is the real problem?
How do we know if any systems are in the mess?
What is our objective?
What do we want to accomplish?
What are our concerns?
What is our challenge?
What wish would we like to fulfill?
- “This step involves DIVERGENT THINKING, so record as many different problem statements as you can begin each statement with the phrase, ‘In what ways might we... or how might we...’ List your group’s thinking on the graphic organizer.”
- S-T-R-E-T-C-H... “Try to create more problem statements. Read over each statement above and ask yourself why you feel it might be the problem. Your answer might reflect another reason, wish, desire, concern or need.
- “Now, generate the answers to more problem statements- beginning with ‘In what ways might we....’”. Record these statements on the graphic organizer.

Preliminary Judgment: *Using your convergent skills, review all your ideas and circle six to eight that seem to have the greatest potential*

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.*

“We have identified the challenge, the facts and a collection of solutions. What do you do next? How have you interacted with the process of creative problem solving? How do you interact with this system, creative problem solving?”

“We have the mess of broken toys and parts of systems. Some of the toys may still work or have energy. Work occurs when there is a change in position, speed, state or form. Potential energy is stored in toys and exists when the toy is at rest. The toy may still be “ready to go” but in in action. Toys in action show kinetic energy. These concepts may be considered when thinking about reverse engineering and making decisions about “the mess”. Show the video of rollercoaster. The video is being used to demonstrate potential and kinetic energy.

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

Stage 4: More Problem Finding

- “Now apply CONVERGENT THINKING to judge and select the most important problem statement. Review all your problem statements and select the one statement or combination of statements that best describes the real problem. Determine which statement you believe will provide the most benefits when

solved. “

“Rewrite the selected problem statement on the graphic organizer under ‘More Problem Solving’. Make sure that your statement calls for ideas to answer it. “

Stage 5: Idea Finding:

- “Answer your problem statement with many ideas in as many different ways as possible. **DIVERGENT THINKING**, combines with deferred judgment, is critical in this step. Your goal is to generate lots of ideas. Try to find as many ideas as you can before you discuss each and become selective. Think of a least 25 ideas.”
- “The essence of the deferred judgment principle is to allow a period of time for listing all the ideas that come to mind without judging them. Quantity of ideas and complete freedom of expression without any evaluation are key concepts **S-T-R-E-T-C-H** your mind to break old habits of thinking.
- “Feel free to combine or modify any ideas to produce additional ideas. Divergent behavior must prevail. Let your ideas flow freely without internal or external criticism. Let the problem incubate- let the problem and ideas rest for a minute to generate additional ideas.”
- Let your divergent process create ideas. Start listing them on the graphic organizer. If you need more paper, it will be provided. **RECORD ALL IDEAS.**

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

Stage 6: Solution Finding

- “As engineers, implementing the discipline of reverse engineering, you must now decide what criteria, standards or benchmarks should be used to weigh the worth of your selected ideas. “
- “These criteria will be used to determine the best solutions to your problem.”
- Considerations for criteria: time, complexity of implementation, quality of products, improvements, complexity of interaction, duplication, ethics, safety, adequate supplies
- “Let your **DIVERGENT THINKING** create a preliminary list of factors or criteria that will be used to evaluate your ideas. Write the list on the graphic organizer.

Selection of Criteria

- “Using your **CONVERGENT THINKING**, review your criteria listed and circle the five or six which you feel to be the most critical for evaluating your ideas.”
- “Now, use a 10 – point scale to weight your selected criteria (10 is high).”
- “When you are satisfied with your criteria, record them on the decision matrix on the following sheet.”

More Solution Finding

- “Using your **CONVERGENT THINKING**, implement a 3-point scale to weight your ideas. (3 is high) as you compare each against the criteria.”
- “If an idea rates very highly against a criterion, then multiply the weighting factor with the criterion weighting factor and post the product in the appropriate column.”
- “The ideas(s) with the highest product should be the most useful.”
- “Rewrite the ideas you think that should be implemented on the graphic organizer.”

Stage 7: Interactive Acceptance Finding – Action Plan!

“We cannot solve problems with the same thinking we used to create them.” Albert Einstein

- “Engineers, this is where you develop your plan of action in creative problem solving.”
- “How should you modify your idea so it will be as acceptable as possible to those it will affect and to those who will pass judgment on it?”
- “Ask yourself questions along with others that are relevant.”
How might I gain the other engineers acceptance in the class?
What resources are needed to implement our idea?
How might we overcome any obstacles?
What might go wrong?

What might go wrong in a system?

What can we do to prevent problems?

What opportunities might be presented?

What should we not do?

When should we not follow a plan because an interaction affects a system?

As engineers practicing reverse, engineering, how might we best gain support for our ideas from the class?

- *"Use your DIVERGENT THINKING skills, list all responses that come to mind answering by the questions based upon the thoughts that come to mind from the questions on the graphic organizer. The scribe will record the responses."*
- *"Use CONVERGENT THINKING skills to select the responses that you believe will ensure success."*

Plan of Action: Develop your plan of action. Gather your thoughts about how your sequential plan of action. What would need to be accomplished to put your plan into action? Who is responsible for each task? Action plans require checkpoints to see if events are happening according to plan. Use the graphic organizer to create your plan."

Reflect by asking the Post Lesson Questions

1. *Why would creative problem solving be a part of reverse engineering?*
2. *Why is interacting with others is a part of creative problem solving?*
3. *How can understanding the goal of a system be a part of creative problem solving?*
4. *How did you interact in each stage?*
5. *How does the system of creative problem solving support the reverse engineering process?*
6. *How did you interact with each other to obtain your goals in creative problem solving?*
7. *How can you ensure the best solution will be implemented in creative problem solving?*
8. *How do interactions affect systems?*
9. *How do systems affect interactions?*

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

Tell the students they are to reflect on the process of creative problem solving. Creative Problem Solving is a valuable life skill tool in making decisions. Teams of engineers have to interact with each other and systems to make decisions about how they want interactions to affect systems.

Share with the students the acronym SCAMPER: substitute, combine, adapt, modify, put to other uses, eliminate, rearrange

Tell the students they are to create an acronym to represent the creative problem solving process. An acronym is an abbreviation that forms a pronounceable word. Artwork may accompany the acronym.

1. *How would this word help others remember the process to make creative sound decisions?*
2. *How would this acronym encourage reverse engineers to creatively solve problems?*
3. *How would the acronym represent how reverse engineers interact with systems to solve problems?*

Post the acronyms on the board and have the children view their peers' acronyms. Have the children make reflective comments on sticky notes and post the reflective comments beside of the acronym.

TEACHER NAME		Lesson #
Kelly Nuckols		Camp lesson 4
MODEL	CONTENT AREA	GRADE LEVEL
Questioning	Science	5th grade
CONCEPTUAL LENS		LESSON TOPIC
Interactions		Reverse Engineering
LEARNING OBJECTIVES <i>(from State/Local Curriculum)</i>		
5.P. 2 Understand the interactions of matter and energy and the changes that occur. RL. 4.7 Interpret information presented visually, orally or quantitatively and explain how the information contributes to an understanding of the text in which it appears.		
THE ESSENTIAL UNDERSTANDING <i>(What is the overarching idea students will understand as a result of this lesson?)</i>		THE ESSENTIAL QUESTION <i>(What question will be asked to lead students to “uncover” the Essential Understanding)</i>
<i>Interactions affect systems.</i>		<i>How does interaction affect systems?</i>
CONTENT KNOWLEDGE <i>(What factual information will students learn in this lesson?)</i>		PROCESS SKILLS <i>(What will students be able to do as a result of this lesson?)</i>
Students will know... Reverse engineering is a process. (Reverse engineering is the process of disassembling and analyzing the product back to be original design or to improve the design.) A system is a group of related or connected parts that move or work together. Interacting with a system creates new ideas in other systems. Components in a system and how they interact to produce movements. Law protects a patent invention so that only particular people or companies have the right to make or sell it.		Students will... Create a new plan and system Apply learning and questioning to create a new product. Design a plan to communicate the parts of a system. Modify the parts of a system to improve the system. Compare and contrast the new system to the original system. Research to gain knowledge and understanding of a system Evaluate a new system.

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 a system? Why were modifications made within the systems? What questions do you think the inventors asked themselves before they interacted with the roller coaster? How did they plan the new system? How did they imagine and create the new interactions? How did they decide the improvements to the system? How do new systems affect older systems? Why do new systems begin? Why do new systems end? Why is there a need to understand and interact with current systems to create new systems? How do people's needs affect the change in systems? How do people's needs affect the way they interact with a system? How can you see the roller coaster changing to meet the entertainment needs of the future?	How are you going to display your toy design? How will you communicate your interactions with the system? How are you going to plan and interact with your design team? (if they are in a team) How are you imagining your toy to improved or even duplicated? How will interacting with the system affect the movements? How can you modify the system? Why do you want to modify it? How can you create new ways to use the toy? When can parts be eliminated from the system? What parts can be used instead of the original parts in the system to create a new interaction? What parts can be substituted to make it more cost effective? Why will your interactions clearly affect the system?	How did you interact with your design team to obtain your goal of reverse engineering? What factors influenced the changes you made in the system? How did your interactions affect the system? How do you compare the new system to the "old" system? How will others understand your purpose in modifying the system? How will others interpret your design plan and see interactions have been made in the system? How would you evaluate your new system?	
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 students will use their knowledge and skills to reengineer a toy and how to promote it. This task will foster a deeper understanding of reverse engineering.	The students may work as a team or individually.

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.

The Rise and Fall of the Roller Coaster

While children are entering the room, have a video of the 10 most popular roller coasters at Kings Dominion playing.

https://www.youtube.com/watch?v=_JMcwjWUT3o

Ask: Who is going to ride The Ice Sled this summer? Who is going to ride the Switch Back Railway this summer? These were the names of roller coasters before they became known as roller coasters.

Before watching the video of the history of roller coasters, discuss with the children what a system is? (A group of related or connected parts that move or work together)

What are examples of systems?

How do systems interact with other systems?

When is it necessary for one system to interact with other systems?

How do you judge when the interactions affect a system positively or negatively?

<https://www.youtube.com/watch?v=eOESYhVZpEY> - Wild Rides 4/6 Roller Coaster History

<http://twistedifter.com/videos/led-black-hole-water-slide-bremerhaven-germany/> - The Black Hole

While watching the video make a list of all of the systems that were affected by the roller coaster's evolution.

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.

Ask Pre-Lesson Questions:

What is a system?

Why were modifications made within the systems?

What questions do you think the inventors asked themselves before they interacted with the roller coaster?

How did they plan the new system?

How did they imagine and create the new interactions?

How did they decide the improvements to the system?

How do new systems affect older systems?

Why do new systems begin?

Why do new systems end?

Why is there a need to understand and interact with current systems to create new systems?

How do people's needs affect the change in systems?

How do people's needs affect the way they interact with a system?

How can you see the roller coaster changing to meet the entertainment needs of the future?

"Like in the video, scientists, historians and engineers have interacted with the roller coaster for many years and for many reasons. They all expanded on an idea or interacted with a system to produce new results. Today, you are going to do a task performance that involves using reverse engineering with a toy or toys."

Have children work in groups of 3 to explore the toys. This is time where they are sharing ideas and questions about the toys and how they would change or improve them. As children investigate the toys, they are to have them craft five questions that a reverse engineer may ponder while investigating a toy system. They are encouraged to begin their questions with "I wonder why or how..." The teacher circulates during this exploration

to monitor groups.

Students share questions and a scribe will post the questions so they are viewed by everyone.

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.

Explain the task performance, The Toy Fair

Show images of the Toy Fair 2015

Your application to debut your toy at the 2015 Toy Fair in New York City has just been accepted. Your design team is working around the clock for the debut. Retro will be all the rage at the Toy Fair. It is a new category that highlights veteran toys with new updates that will appeal to today's curious minds.

There will be an abundance of manufacturers there to land a deal with your design team to produce your reengineered toy. They will be there reading to produce the next in-demand toy that will have children pulling at their parent's pants leg to purchase.

Because your team understands your toy system and the toy interactions, your team will need to create a design plan for manufactures at the trade show to follow and understand so they can reproduce the toy. The plan involves documenting the parts of the toy and how they work together. Along with the design plan, you will need to know how to promote the toy and target the audience your toy will appeal to and offer endless hours of amusement.

Your design team has been selected! Get ready, get set, go design!

Children may work in small groups or they may work by themselves.

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 begin working on the task performance. They need to start out thinking about how they are going to document how the toy is engineered. Are they going to create a power point to record their progress, will they take pictures and document their progress will they create a display?

What is their design plan? How will they communicate the plan to the manufacturers? How will they promote the toy and have it interact with the public's eye and interests?

The students will research the toys by their patent number to see original designs and exploded diagrams. This will assist them in making further connections to the product and understanding the construction by viewing from a 2-D perspective. They will research the toy to see how it has been promoted in the past and make decisions on they want to promote the toy.

During Lesson Questions:

How are you applying the five questions you posed in your small group?

How are you going to plan and interact with your design team? (if they are in a team)

How are you imagining your toy to improved or even duplicated?

How are you going to display your toy design?

How will you communicate your interactions with the system?

How can you modify the system?

Why do you want to modify it?

How can you create new ways to use the toy?

When can parts be eliminated from the system?

What parts can be used instead of the original parts in the system to create a new interaction?

What parts can be substituted to make it more cost effective?

Why will your interactions clearly affect the system?

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

Students share with the class their toys they will enter in the Toy Fair and the design plan.

Post Questions:

How did you interact with your design team to obtain your goal of reverse engineering?

What factors influenced the changes you made in the system?

How did your interactions affect the system?

How do you compare the new system to the "old" system?

How will others understand your purpose in modifying the system?

How will others interpret your design plan and see interactions have been made in the system?

How would you evaluate your new system?

Have the students give their peers feedback on the reengineered toy by having the students interact with each reengineered toy and write reviews on index cards placed by the toys.

Stage 1: **Mess Finding!!**

The first step in taking action is to identify a situation, which presents a challenge... an opportunity... or is a concern you want to do something about or is an objective you desire to attain.

When you recognize a messy situation, it is helpful to write a brief abstract that captures the essence of what is happening right now—or what is not occurring that should be.

- Write your concerns, thoughts, and the changes you would like to see in you situation. LET YOUR THOUGHTS FLOW. Describe the situation below.

Questions that might be helpful include the following: What do you stand to lose if something is not done about the problem? What have you already tried? What good is coming from the current situation?

- Now, summarize and restate the problem using a “How to....” Statement.

Stage 2: **Data Finding**

- List all the key facts associated with your situation or your desired objective, as you perceive them. Ask yourself:

Who is involved?	What is involved?
What are some examples of the problem?	
What causes the problem?	When will it happen?
Where does it or will it happen?	Why does it happen?
Are there any more problems caused by the situation?	

Then ask questions pertaining to what additional facts you would like to know and where you might search for them. Your goal is to have all the knowledge pertinent to the situation so that you can identify and define the key problems.

- Now use DIVERGENT THINKING to brain storm all the known facts. List all known facts in the space below.
- What facts are lacking? Who has the answer? List them below.

- Now, apply CONVERGENT THINKING to judge and select the most important facts. Circle most significant facts and those that provide a key to your situation.

Stage 3: **Problem Finding**

Considering the data you have gathered about your situation during Fact Finding, determine what you want to accomplish in more specific terms. Ask yourself the following questions.

What is the real problem?
 What is my objective?
 What do I want to accomplish?
 What are my concerns?
 What is my challenge?
 What wish would I like to fulfill?

- This step involves DIVERGENT THINKING; so record as many different problem statements as you can. Begin each statement with the phrase “In What Ways Might We...” (IWWMW) or “How Might I...” (HMI)
- S-T-R-E-T-C-H ...Try to create more problem statements. Read over each statement above and ask yourself why you feel it might be the problem. Your answer might reflect another reason, wish, desire, concern or need.

Now, use the answers to generate more problem statements....beginning with IWWMW...

Stage 4: **MORE PROBLEM FINDING!!**

Now, apply CONVERGENT THINKING to judge and select the most important problem statement.

Review all your problem statements and select the one statement or combinations that best describes the real problem. Determine which statement you believe will provide the most benefits when solved.

- Rewrite the selected problem statement. Make sure that your statement calls for ideas to answer it.

Stage 5: **Idea Finding**

Try to answer your problem statements with many ideas in as many different ways as possible. Use DIVERGENT THINKING, combined with deferred judgment, is critical in this step. Your goal is to generate lots of ideas. It is often helpful to set a number goal before you start listing ideas. Try for 50 -75 ideas before you discuss each and become selective.

The essence of the deferred judgment principle is to allow a period of time for listing all the ideas that come to mind without judging them. Quality of ideas and complete freedom of expression without any evaluation are key concepts. S-T-R-E-T-C-H your mind to break old habits of thinking.

Feel free to combine or modify any ideas to produce additional ideas. Divergent behavior must prevail. Let your ideas flow freely without internal or external criticism. If time permits, incubate – let the problem and ideas rest in your subconscious for a time – to generate additional ideas.

- Let your divergent thinking process create ideas. Start listing them below—continue on additional sheets of paper. RECORD ALL IDEAS.
- **Preliminary Judgment-** Using convergent skills review all your ideas and circle six to eight that seem to have the greatest potential.

Stage 6: **Solution Finding**

You must now decide what criteria or standards should be applied to weigh the worth of your selected ideas. These criteria will be used to determine the best solution(s) to your problem. Your ideas affect cost, time, reliability, quality, morale, customers, legality, safety, company practices and approvals, feasibility, timeliness and ease of implementation. Any or all of these, as well as others, can be considerations for criteria.

- Let your DIVERGENT THINKING create a preliminary list of factors or criteria that will be used to evaluate your ideas. Write the list below.

Selection of Criteria

Using your CONVERGENT THINKING, review your criteria listed above and circle the five or six, which you feel to be the most critical for evaluation, your ideas.

Now, use a 10 – point scale to weight your selected criteria. (10 is high)

When you are satisfied your criteria, record them on the below.

Stage 7: **More Solution Finding**

- Using your CONVERGENT THINKING, implement a 3 – point scale to weight your ideas (3 is high) as you compare each against the criteria. If an idea rates very highly against a criterion, then multiply the idea's weighting factor with the criterion weighting factor and post the sum.
- Rewrite the idea(s) you are going to implement.

Stage 8: **Acceptance Finding**

You are now ready to develop your plan of action. To ensure successful implementation of your best idea(s), it is necessary to gain maximum acceptance. Remember, an idea has little value until it is put to use.

Consider the following – How should you alter or modify your idea so it will be as acceptable to those it will affect and to those who will pass judgment on it? Ask yourself the following questions along with others that are relevant.

Whom will my idea affect?

How might I gain their acceptance?

What resources are needed to implement my idea?

What major obstacles will I confront?

What might go wrong?

Why would something go wrong?

What can I do to prevent problems?

What opportunities might present themselves?

What should I not do?

- **Gaining Acceptance**—Using DIVERGENT THINKING skills, list all responses that come to mind by asking and answering the most important questions, based upon the stimuli provided above.
- Use CONVERGENT THINKING skills to select the responses that you believe will ensure success.

Plan of Action

Develop your plan of action. Remember, the proactive individual makes the right things happen on time.

- Gather the best thoughts from your acceptance finding and develop your plan of action.

The Toy Fair – Performance Task

You are a product designer in demanding world of toy design. Your application to debut your newly designed toy at the 2016 Toy Fair in New York City has just been accepted. Your design team is working around the clock for the debut. Retro will be all the rage at the Toy Fair. It is a new toy category that highlights veteran toys with new updates that will appeal to today's curious minds.

There will be an abundance of manufacturers there to land a deal with your design team to produce your reengineered toy. They will be there ready to produce the next in-demand toy that will have children pulling at their parent's pants leg to purchase.

Because your team understands your toy system and the toy interactions, your team will need to create a design plan for manufacturers at the trade show to follow and understand so they can reproduce the toy. The plan involves documenting the parts of the toy and how they work together. Along with the design plan, you will need to know how to promote the toy and target the audience your toy will appeal to and offer endless hours of amusement.

Your design team will allow another toy product designer group in our class to take a sneak peek at your newly designed toy. They will give you written feedback before you make your grand debut at the Toy Fair. Make sure you have the following ready for your peers' sneak peek.

- **A diagram of the toy parts-** so the manufacturer knows the inside details know the inside of the system
- **A promotion poster or visual for the toy** – so the manufacturer knows the targeted audience; how and why someone interacts with the new system; how does the visual affect someone's perspective of the new system.
- **The newly designed toy-** the new system

The feedback your peers provide you will be completed on the Performance Task Rubric.

Reverse Engineering Unit Resources



Books

Who Was Steve Jobs?

This is high interest book about Steve Jobs. Students read to see how he was an expert in the field of technology and science and how he interacted to systems to create something and better.

Pollack, P., & Belviso, M. (2012). *Who was Steve Jobs?* New York: Grosset & Dunlap

Inventing Toys and Kids Having Fun Learning Science

This is a resource book for teachers and students that want to investigate a toy system through engaging creative workshops.

Sobey, E. (2002). *Inventing toys: Kids having fun learning science*. Tucson, Ariz.: Zephyr Press.

The Way Toys Work The Science Behind the Magic 8 Ball, Etch A Sketch, Boomerang, and More

Students read about the history of toys, technology incorporated in toys and view exploded images of the toys along with the patent numbers. Children are given tips on how to create their own version of the toy.

Sobey, E., & Sobey, W. (2008). *The way toys work the science behind the magic 8 ball, etch a sketch, boomerang, and more*. Chicago, Ill.: Chicago Review Press.

Mechanical Toys: How Old Toys Work

This is a resource book for teachers and students that want to understand the origin of toy, the enchantment of toys, mass production of toys, toys that predicted the future, mechanisms in toys and sounds and other surprises.

Spilhaus, A., & Spilhaus, K. (1989). *Mechanical toys: How old toys work*. New York: Crown.

Forces and Motion

This is a friendly Ranger Rick resource that introduces how forces cause motion, pushing and pulling concepts, ways we move, types of gravity, the force of gravity, forces in nature and simple machines. The book reinforces content vocabulary with detailed explanations and photographs.

Trumbauer, L. (1988). *Forces and Motion*. New York, New York: Newbridge Educational Publishing

Videos

History Channel UFO Hunters 107 Reverse Engineering

www.youtube.com/watch?v=INgY7UtxLSs

This video highlights an interesting idea of a UFO where a group of reverse engineers work together to study an aircraft. They imagine possibilities and recreate the aircraft. There is an issue of ethics are recreating ideas. The engineers use various disciplines such as physics and geometry to study the aircraft.

Strawbees-Kickstarter

www.kickstarter.com/projects/1624049406/strawbees-dream-big-build-bigger

This is playful video about inventing a new item and recreating ways to interact with other items. The team demonstrates different movements a simplebee can generate.

Taking Stuff Apart

www.youtbe.com/watch?v=YvZ3-JRKXuQ

This is a high-energy video of a man taking apart a microwave. He inquires about the parts and organizes them.

Furby Autopsy

<http://vimeo.com/90741916>

This is a video of a Furby being taken apart and analyzed.

Roller Coaster

<http://www.youtube.com/watch?v=dpBVtAbKJU>

This is a video is used to demonstrate potential and kinetic energy.

The Rise and Fall of the Roller Coaster

https://www.youtube.com/watch?v=_JMcwjWUT3o

This is a video of the 10 most popular roller coasters at Kings Dominion.

Wild Rides4/6 Roller Coaster History

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

The Black Hole

<http://twistedifter.com/videos/led-black-hole-water-slide-bremerhaven-germany/>

These two videos offers great discussion on how one system affects another system in history and in science.

Other Resources

Break It Down: Reverse Engineering. (2009, December 16). Retrieved August 4, 2015, from <http://teachers.egfi-k12.org/>

Crosby, J., & Surles, W. (2009, August 3). Build a Toy Workshop. Retrieved August 4, 2015, from <http://www.teachengineering.org/>

Curricular Unit: Creative Engineering Design. (n.d.). Retrieved August 4, 2015, from <http://www.teachengineering.org>

Genuine Pictures, Inc., (2011). *The London Eye*. [Video Segment]. Available from <http://www.discoveryeducation.com>

Graybill, G. (2007). *Simple machines*. San Diego, CA: Classroom Complete Press.

Levine, A. (n.d.). Reverse Engineering and Redesigning Everyday Products Leads to Surprising Recommendation. Retrieved August 4, 2015, from <https://www.asme.org/>

Megan, S., & Malinda, Z. (2015, January 16). Hands-on Activity: Engineering in Reverse. Retrieved August 4, 2015.

Smith, R. (2014). Physical Science: Simple Machines, Motion. *Science Investigations*. Westminster, CA: Teacher Created Resources.