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LIBM 461

Guided Inquiry Lesson

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1. Lesson Title: Rollercoaster!

2. Lesson Author: Jessica Dufresne. I am currently a second grade teacher at Daly Elementary in Hamilton, MT. Previously, I taught for 13 years in Darby. My years at Darby were in Gifted and Talented, Second Grade, and Title I. I am hoping to become a librarian in the Hamilton School District when an opening arrives. I recently attended a several workshops at the MT AGATE Conference that were presented by academic coaches from Bozeman, MT. The inspiration for

this inquiry based project comes from their Genius Hour and Problem Based Learning workshops. During a workshop I attended, we built our own rollercoasters as a group and learned how to create a Problem Based Learning unit. In digging around for this lesson, I was thrilled to find that there are many resources and ideas available to pull from. Ultimately, the most helpful was a lesson from Teach Engineering, Curriculum for k-12 teachers. There were also many ideas and articles found in journal articles on EBSCO. Many of the ideas, questions, and handouts came from the Teach Engineering website and lessons found in journal articles. The idea for this inquiry based learning project is not a new one (although, admittedly, I thought it was new when I participated in the workshop at AGATE, and didn't realize all the resources for the unit until I started digging around!) but I believe it's highly engaging and a highly effective way to teach physics to 8th grade students. The Google Research and Google Docs ideas in the lesson where taken from workshops attended at Googlefest! in Missoula.

3. Curriculum / Subject of Lesson: This lesson is written for a middle school science class. It has cross – curricular ties to Mathematics, English Language Arts, and Technology. This lesson would best fit into a unit focus on Physics / Objects in Motion / Mechanical Systems. In this unit, students will build their own small scale model of roller coasters using pipe insulation and marbles, and then analyze the roller coasters using physics principles. The Library Media Center and the Library Media Specialists are involved as a space for students to work in, a source of reference materials, a collaborative partner in the lesson, and a teacher for help in searching techniques.

4. Grade Level of the Lesson: 8th grade

5. Lesson Duration: (this is dependent on how often the class meets). In a five day a week, 45 minute classroom setting, this lesson will take two and a half weeks.

6. Lesson Materials / Resources:
    a. For the roller coaster building itself: masking tape, marbles, 3-4 segments of foam tubing (used to insulate around pipes, has a natural tunnel for marbles to run down)
    b. Student journals and folders in order to keep their materials together.
    c. Student iPads or Chrome books for advertisement creation.

7. Lesson Overview / Rational: This lesson was created to cover motion and forces for the Montana State Science Standards for 8th Grade. It is meant to be a highly engaging, challenging, and motivating project that incorporates technology, research, and physical science. During the design of model roller coasters, students will encounter many of the same issues that real-world roller coaster engineers face. In order to build working roller coasters, students must recognize the constraints placed on their designs and the design of real roller coasters by the fundamental laws of physics. Students learn that their ability to understand and work.

8. Essential Questions:
    a. How can we create a roller coaster that is entertaining and thrilling while at the same time instills a sense of risk and danger that is exciting to riders? How can we use the laws of physics to create a roller coaster that maximizes thrill and minimizes risk of danger to a rider?
    b. What would happen if engineers ignored the fundamental laws of physics in their designs?
    c. How important is it to you that engineers test their designs (for appliances, cars, bridges, stairways, roller, coasters, etc.) before they are built and people use them?

9. Goals: To teach and reinforce the concepts of speed, acceleration, the laws of motion, the forces associated with motion, potential and kinetic energy transfer. Cross-curricular, students will be able to demonstrate use of the Google Research tool, cite references found on the internet, answer comprehension question after reading a non-fiction piece, and create a persuasive advertisement for a rollercoaster.

10. Objective: At the conclusion of this units, the students will be able to:
    a. Explain in physics terms how their model roller coasters work
    b. Discuss the effects of gravity and friction in the context of their roller coaster design
    c. Identify points on a roller coaster track where the car accelerates and decelerates.
    d. Work cooperatively in order to design a roller coaster.
    e. Research roller coaster physics and demonstrate use of the Google Research app within Google Docs.
    f. Design an advertisement for a roller coaster.

11. Standards:
    a. Standards National: NETS-S
        i. Creativity and Innovation: Students create demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology.
            1. Apply existing knowledge to generate new ideas, products, or processes.
            2. Use models and simulations to explore complex systems and issues
        ii. Communication and collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
            1. Communicate information and ideas effectively to multiple audiences using a variety of media and formats.
            2. Contribute to project teams to produce original works or solve problems.

iii. Research and information fluency: Students apply digital tools to gather, evaluate, and use information.
    1. Plan strategies to guide inquiry.
    2. Locate, organize, analyze, evaluate, synthesize and ethically use information from a variety of sources and media.
iv. Critical thinking, problem solving and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
    1. Identify and define authentic problems and significant questions for investigation.
    2. Plan and manage activities to develop a solution or complete a project.
    3. Collect and analyze data to identify solutions and / or make informed decisions.
    4. Use multiple processes and diverse perspectives to explore alternative solutions.

b. Standards National: 21st Century AASL
    i. Learners use skills, resources, and tools to inquire, think critically, and gain knowledge.
        1. 1.1.1 Follow an inquiry based process in seeking knowledge in curricular subjects, and make the real world connection for using this process in own life.
        2. 1.1.2. Use prior and background knowledge as context for new learning.
        3. 1.2.1. Display initiative and engagement by posing questions and investigating the answers beyond the collection of superficial facts.
        4. 1.2.5. Demonstrate adaptability by changing the inquiry focus, questions, resources, or strategies when necessary to achieve success.
    ii. Learners Use Skills, Resources, and Tools to: Draw conclusions, make informed decisions, apply knowledge to new situations, and create new knowledge.
        1. 2.1.1. Continue an inquiry based research process by applying critical thinking skills to information and knowledge in order to construct new understandings, draw conclusions, and create new knowledge.
        2. 2.1.2 Organize knowledge so that is useful.
        3. 2.1.5 Collaborate with others to exchange ideas, develop new understandings, make decisions, and solve problems.
        4. 2.2.4 Demonstrate personal productivity by completing products to express learning.
        5. 2.4.1 Determine how to act on information
    iii. Learners use skills, resources, and tools to share knowledge and participate ethically and productively as members of our democratic society.
        1. 3.1.1 Conclude an inquiry based research process by sharing new understandings and reflecting on the learning.

2. 3.1.3. Use writing and speaking skills to communicate new understandings effectively.
3. 3.2.3 Demonstrate teamwork by working productively with others.
4. 3.3.4 Create products that apply to authentic, real world contexts.

iv. Learners use skills, resources, and tools to pursue personal and aesthetic growth.

1. 4.3.2 Recognize that resources are created for a variety of purposes.
2. 4.2.3. Maintain openness to new ideas by considering divergent opinions, changing opinions or conclusions when evidence supports the change, and seeking information about new ideas encountered through academic or personal experiences.

c. Standards State: MT Library / Information Literacy
   i. Information Literacy / Library Media Content Standard 2
      1. Locate multiple resources using search tools
      2. Locate information within multiple resources
      3. Extract information from multiple resources needed to solve the problem
      4. Organize and manage information to solve the problem
   ii. Information Literacy / Library Media Content Standard 3
      1. Assess the quality and effectiveness of the product
      2. Evaluate the process in order to revise strategies
d. Standards State: MT Technology
   i. Content Standard 1: A student must use digital tools and resources for problem solving and decision making.
      1. Use multiple approaches to explore alternative solutions.
      2. Collect relevant data and information on a subject from a variety of digital resources.
      3. Share data and information ethically and appropriately cite sources.
   ii. Content Standard 3: A student must apply digital tools and skills with creativity and innovation to express his / herself, construct knowledge and develop products and processes.
      1. Apply a variety of digital tools for personal and group expression.
      2. Use a variety of digital tools to create a product.
e. Standards State: Subject Content Standard
   i. Science Content Standard 1: Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate the results and form reasonable conclusions of scientific investigations.
      1. 1.3 review, communicate and defend results of investigations, including considering alternative explanations.
      2. 1.4 create models to illustrate scientific concepts and use the model to predict change.
      3. 1.5 identify strengths and weaknesses in an investigation design.

ii. Science Content Standard 2: Students, through the inquiry process, demonstrate knowledge of properties, forms, changes, and interactions of physical and chemical systems.
    1. 2.5 describe and explain the motion of an object in terms of its position, direction and speed as well as the forces acting upon it.
    2. 2.6 identify, build, describe, measure, and analyze mechanical systems and describe the forces acting within those systems.

12. Technology Used:
    a. Internet: Students will use various internet sources in order to conduct their research. The SMLC will conduct a lesson that demonstrates the use of the Google Research application and discuss citation and fair use of pictures.
        i. Students will also use the roller coaster simulator located at: http://www.jason.org/digital_library/4851/coaster-creator
    b. iPads: iPads and different "apps" will be available for student product choices.
    c. Chrome Books will be available for student product choices.

13. Collaboration
    a. Classroom Teacher: Will serve as "point" person for the lesson. Responsible for student assessment and guiding students through the process. The classroom teacher seeks to model an inquiry stance of questions and be open and responsive to students. In discussions, the teacher will attempt to listen to good ideas and ask questions that draw out what students know and are interested in.
    b. School Librarian: Will collaborate with the classroom teacher throughout the process. At one point, the SMLC will conduct a lesson that demonstrates the Google Research application in Google Docs. Citation and fair use of pictures will be discussed. The SMLC will also display books about rollercoasters and create a "symbaloo" for the class to use.
    c. Instructional Team: The Mathematics teacher and ELA teacher will collaborate with the team as students' progress through the process. Different applications of the idea will be presented in their classes. The team seeks to model interaction and openness in an accepting environment.

14. Anticipatory Set (this anticipatory set is drawn from: https://www.teachengineering.org/view_activity.php?url=collection/duk_/activities/duk_rollercoaster_music_act/duk_rollercoaster_music_act.xml)

    a. Teacher will show students the video https://www.youtube.com/watch?v=i38qZqANZtM
    (or a similarly engaging video about riding a roller coaster!)
    Students will also enjoy looking at pictures of roller coasters at: http://www.ultimaterollercoaster.com/coasters/pictures/

Students might also enjoy having the teacher read “Holy Batman! The ride. “
Start by having students draw a roller coaster on paper, giving it a fun and descriptive name and making a sign for it.

Discuss with students what makes a roller coaster fun. Write their answers down on chart paper or use “Popplet” or “Pearl Trees” projected onto the white board to record their answers. **Discuss how when engineers design objects and structures, they must work within “constraints”.** Constraints are project requirements and / or limitations. Engineers must take into consideration these constraints in order to come up with successful design solutions.

In the case of designing roller coasters, what might be some constraints that engineers would have to consider? (Let students think about this and make suggestions). Yes, they might have some practical limitations, such as available or preferred building materials, a construction budget and timeframe, safety measures for users, ongoing maintenance requirements and / or anticipated weather conditions. The amusement park client may also give requirements for the type of movement they want for the ride (upside down loops, corkscrews, specific degree turns, length of drops or maximum speed, or safety assurances for users). Another basic constraint that always applies is consideration of the natural physical laws that exist in our world, such as the limits of gravity and effects of slope, speed and friction.

When designing your roller coaster, what are the physics concepts that you have learned that will be helpful and very important to apply?
All true roller coasters are entirely driven by the force of gravity. The excitement of a ride comes from the ongoing conversion between potential and kinetic energy, which we know from the law of conservation of energy. Friction is important to slowing down roller coaster cars and acceleration plays a role in the experience provided by roller coaster cars as they move along a track.

How do these concepts translate to your challenge to design a roller coaster that provides a thrilling experience that is safe for riders?
Possible student answers, and answers to draw out are:

- The top of the first hill must be the highest point of the roller coaster
- Cars move fastest at the bottoms of hills and slowest at the top of hills.
- Friction converts useful energy into heat and must be minimized.
- G-forces greater than 1 occur at the bottom of hills
- G-forces less than 1 occur at the tops of hills
- To avoid falling, cars must have a certain velocity at the top of loops.

These are constraints that we must take seriously! The first hill must be the highest point or the roller coaster won't work. If a car is not moving fast enough at the top of a loop, it will fall off the track. Pay attention to the friction between the car and the track, making it as small as you can so the cars move fast enough to make it through the entire track. Let's get started!

Teachers may wish to draw on their previous knowledge by creating a KWL chart during the discussion period. After introducing the unit, discuss the students learning journals and their folders for their handouts / research findings.

15. And 16. Process Model and Step by Step Activities
    a. This lesson uses Guided Inquiry Design Framework

Open	Invitation to Inquiry Open Minds Stimulate curiosity	Day 1: Anticipatory set (see above) Collaborate in inquiry community (whole classroom). Teacher creates inquiry circles for completing the project.
Immerse	Build background knowledge Connect to content Discover interesting ideas	Day 2: Teach background knowledge using: https://www.teachengineering.org/view_lesson.php?url=collection/duk_/lessons/duk_rollercoaster_music_less/duk_rollercoaster_music_less.xml SMLC – pull and display books about rollercoasters. Create a "symbaloo" with various websites, videos, and information about rollercoasters. An example is here: http://www.symbaloo.com/home/mix/elementaryscience2 Students use inquiry journal to record their background knowledge and connections.
Explore	Explore interesting ideas Look around Dip in	Day 3: Use roller coaster model websites to create virtual roller coasters. http://www.jason.org/digital_library/4851/coaster-creator Day 4: SMLC – discuss ways to find information about roller coaster physics. Google Research tool and discussion on how to cite sources and use pictures. An example is here: https://www.youtube.com/watch?v=NGtWyifMX_k Students journal their ideas and progress. Also possible to create a blog for journaling or use podcasting. Day 5: Create roller coasters using tubing and marbles. Allow 30 minutes for brainstorming and ten minutes for building. Test marble tracks. Use inquiry log to divide information and results from trial run into "I may use this" and "I will use this".
Identify	Pause and ponder Identify	Day 5 or 6: Discuss results of first trial run. Revisit and troubleshoot with kids. Day 6: Give students various sizes of marbles and give

	inquiry question Decide direction	students time so they are able to test their tracks and make necessary changes. Day 7: Stage a class competition and video student's roller coasters using the iPad.
Create	Reflect on learning Go beyond facts to make meaning Create to communicate	Day 7: Have a class discussion (see attached discussion questions) and have students complete a "roller coaster specifications" and scoring rubric to assess their rollercoasters. Day 8 – 10: Students then create an advertisement for their rollercoaster, using a product choice rubric.
Share	Learn from each other Share learning Tell your story	Day 11: Share videos of foam rollercoasters and share design products. If possible, open up their presentations to other classes or parents and/or post to a blog so that students have a broader audience for their product. Students should share their story and identify what they learned from each other. Another possibility is to create a document or advertisement with a QR code and have students display their projects throughout the building or at different community centers.
Evaluate	Evaluate achievement of learning goals. Reflect on content Reflect on progress	Day 12: Collect and discuss earlier rubrics on rollercoaster specifications and roller coaster scoring rubric. Student podcast or journal reflection that evaluates their achievement of learning goals, reflects on the content, and the process. Inquiry journal entry or podcast. SMLC, classroom teacher, and other participants meet to discuss the unit.

17. Lesson Closure / Reflect Anticipatory Set: View videos of student's rollercoasters and read journal entries and listen to podcasts. Discuss as a class:

Which roller coasters were most exciting? Which were safest?

Which won for creativity? Which won for performance and safety?

Which model best met the overall challenge for both thrilling design and safety? What were the trade offs?

What did you learn from testing your model?

If you were to redesign your roller coaster, what improvements would you make and why?

What would happen if you / engineers ignored the fundamental laws of physics in your / their designs?

How important is it to you that engineers test their designs before they are built and people use them?

What problem solving techniques did you use to create your roller coaster and solve the problem?

Which advertisements were the most creative? Which would you most likely want to visit?

18. Lesson Evaluation / Assignments / Handouts / Teaching Materials:

Check that each group understands how and why its roller coaster works. If a roller coaster is not working, ask students what they think the problem is. See if they can identify physics constraints and explain problems in physics terms.

The Roller Coaster Specifications Worksheet can be found here: https://www.teachengineering.org/collection/duk_/activities/duk_rollercoaster_music_act/roller_coaster_worksheet.pdf

The Roller Coaster Suggested Scoring Rubric can be found here:

https://www.teachengineering.org/collection/duk_/activities/duk_rollercoaster_music_act/scoring_rubric.pdf

A possible product choice menu is here:

Create an advertisement for your roller coaster using the app “Comic Life”. Make sure to include persuasive words and pictures to entice people to ride your rollercoaster!	Use iMovie to create an advertisement for your rollercoaster. Include a copy of your story board in your final presentation.	Use Google Docs to create a pamphlet for your rollercoaster. Include pictures and citations.
Narrate a podcast that is a radio advertisement for your rollercoaster. Keep it under 4 minutes! Create a QR code for the podcast and paste it into Google Doc.	Draw (or use whatever medium you feel comfortable with) a poster for your rollercoaster. Display the poster in the classroom.	Use Google Slides to create a presentation for your rollercoaster.

A sample rubric for the advertisement is here:

The advertisement has a title or heading and the content is focused on the rollercoaster.	1	2	3	4
Artwork, if present, is nicely executed and spelling, punctuation, and grammar are accurate.	1	2	3	4
The presentation / product indicates an understanding of the material.	1	2	3	4
Ad copy is well written and appropriate	1	2	3	4
The ad represents the student's full potential.	1	2	3	4

For connections to an authentic audience, a possibility is to have the student post Google Docs with QR codes to their projects around the school or in the community.

19: Connection to Other Curricular Areas:

English Language Arts: A quick search on http://www.ReadWorks.org for "rollercoaster" gives several great ideas for connecting content to ELA. Students could do a close read, practice their fluency and comprehension, and learn non-fiction text features while working on Rollercoaster!

http://www.readworks.org/passages/energy-screams

Math: Students will use math in calculating velocity. Math could also be incorporated by using budget as one of the constraints in their design. Students could calculate material cost, etc. and take that into consideration in building their roller coaster.

20: Adapted Learning

7. Adaptations for students with learning disabilities – Eliminate some of the physics exploration behind the lesson and have students build their roller coasters and discover

for themselves the concepts that are discussed. Focus on the basic explanations of friction and gravity. Students may also want to use the podcasting option for their journal entries, rather than write, and use iPad apps like “Notability” to read information to them when needed.

8. Adaptations for gifted learners – Introduce equations for potential and kinetic energy so students can calculate both forms of energy and verify the law of conservation of energy. Have students explore loops along with the concept of critical velocity. Have students find the starting height of a roller coaster necessary to complete a loop of a given height.

References

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