While listening to the Jade Rabbit discussion in the seminar I decided that my robotics lesson could use an overhaul and be modified to use content from current events. By incorporating the lunar rover from China to the use our robots here, students can see how the design, building, and use of robots here in an elementary school setting is not all that different than what was probably done in China. Taking it a step further, engineers in China had to design, test, and modify their designs before going off to space. This is a great way to use abstract ideas of foreign countries and engineers to actual hands-on activities that students can do mimicking what adults do in the real world.

I. Title of Lesson: Robotics: Engineering & Design

II. Grade Level and Subject Area: 4th grade, various subject areas (modifiable to 3rd/5th)

III. Standards

A. NGSS

4-PS3 Energy
PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object. PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide. PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
3-5-ETS1 Engineering Design

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

B. CCSS Mathematics

Operations & Algebraic Thinking

Use the four operations with whole numbers to solve problems.

OA.A.3: Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Measurement & Data

Solve problems involving measurement and conversion of measurements.

MD.A.1: Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec.

MD.A.3: Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

Geometric measurement: understand concepts of angle and measure angles

MD.C.5.b: An angle that turns through n one-degree angles is said to have an angle measure of n degrees.

MD.C.6: Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.

Geometry

Draw and identify lines and angles.

G.A.1: Draw points, lines, line segments, rays, angles, perpendicular and parallel lines.

C. CCSS Writing

Text Types and Purposes

W.4.1: Write opinion pieces on topics, supporting a point of view with reasons and information.

W.4.1.b: Provide reasons that are supported by facts and details.

W.4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

W.4.2.b: Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.

W.4.2.d: Use precise language and domain-specific vocabulary to inform about or explain the topic.

Production and Distribution of Writing

W.4.4: Produce clear and coherent writing in which the development and organization are appropriate to task, purpose, and audience.

Research to Build and Present Knowledge

W.4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8: Recall relevant information from experiences. Take notes and categorize information.

Range of Writing

W.4.10: Write routinely over extended time frames and shorter time frames for a range of discipline-specific tasks, purposes, and audiences.

D. CCSS Speaking and Listening

Comprehension and Collaboration

SL.4.1.b: Follow agreed-upon rules for discussions and carry out assigned roles.

SL.4.1.c: Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.

SL.4.3: Identify the reasons and evidence a speaker provides to support particular points.

Presentation of Knowledge and Ideas

SL.4.4: Recount an experience in an organized manner, using appropriate facts and relevant, descriptive details; speak clearly at an understandable pace.

SL.4.5: Add audio recordings and visual displays to presentations.

SL.4.6: Differentiate between contexts that call for formal English and situations where informal discourse is appropriate, use formal English when appropriate to task and situation.

E. CCSS ELA-Literacy

Foundational Skills

Fluency

RF.4.4: Read with sufficient accuracy and fluency to support comprehension.

RF.4.4.a: Read grade-level text with purpose and understanding.

Informational Text

Key Ideas and Details

RI.4.1: Refer to details and examples in a text when explaining what the text says.

RI.4.3: Explain procedures, ideas, or concepts in a scientific, or technical text, based on specific information in the text.

Craft and Structure

RI.4.4: Determine the meaning of domain-specific words or phrases in a text relevant to

grade 4.

Integration of Knowledge and Ideas

RI.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.

IV. Engaging Context: We will begin by asking students to pair-share about their knowledge of robots. Perhaps a quick write, then a share out. We will read aloud (while using the projector to show the visuals) of the book *What are Robots*. Students will be presented with a video-infused PowerPoint on our school's and CalPoly Pomona's Robotics Challenge. They will also see a live demonstration of what the Lego Robotics can do. The video clips and demonstration will feature the robots following an obstacle course. Students will watch and research China's Jade Rabbit from the literary historical aspect to the reasoning of naming the lunar rover by that name.

V. Measurable Objectives: By the conclusion of this time frame students are able to design, program, and construct a functioning robot that will complete the obstacle course challenge. The students design a program to generate a set of instructions to the robot in order to complete the task. Students become familiar with programming terms, and vocabulary specific to the building of the robot. Students will need to formulate a plan for their program, revise it as needed, and analyze any changes, which need to be made.

VI. Total Time: Two Parts, each part consisting of three 60 minute days. Obviously a class or instructor with limited familiarity to Lego Robotics, or with an impacted schedule will need to accommodate how much time to dedicate to this project.

Materials List:

- (5) Lego Mindstorm kits
- Paper, pencil, journal books, notecards
- Laptop (internet Wi-Fi not required)
- Glossary of parts (pictures) and terms for teacher reference
- Glossary of programming icons and their use for teacher reference

Web references:

•http://www.lego.com/en-us/mindstorms/?domainredir=mindstorms.lego.com

• http://www.nxtprograms.com/

• http://firstlegoleague.org/sites/default/files/Challenge/TeamResources/SeniorSolutions/2012Programming1.pdf

•https://www.youtube.com/watch?v=KbxwiIZQIMw (visual telling of the Jade Rabbit of the Moon)

• https://www.youtube.com/watch?v=ht4_hJBHejA (Yutu landing)

• http://www.nature.com/news/china-s-lunar-rover-limps-into-another-long-night-1.15428 (article on Yutu)

• http://www.bbc.com/news/science-environment-26153520 (article)

• http://www.bbc.com/news/science-environment-25763168 (article)

Procedure:

Engineering (and Science)

Day One	Students will have the book *What is a Robot?* Read to them. Discuss. Students will be shown an introductory video on what the Lego Mindstorm robotics program is. This is an exciting teacher made video as it incorporates photos and videos of real students from the school working on the design, programming, and competition. Students will be put in teams of 5. The team members will decide which role they will play in the team. While all members will be exposed to all components of the lesson, they will have specialized roles with additional duties. Roles will be picked out either randomly, or based on student's strength (if known). Roles: Materials Manager: will make sure all members have the Lego pieces, journals, books, and handouts. Checker: will ensure that the objectives of the task are being met. Will go ask for clarification. Encourages team members. Recorder: Responsible for taking down primary notes for the group. While all team members are responsible for the notes, the recorder will have the most accurate up-to-date notes that others can refer back to. Time Keeper: Makes sure the team is working efficiently and watching the time constraints for the day's assignment. Traveler: Unlike the materials manager, this person goes

	to other teams to collaborate and gain insight from other members. This person also will have the primary duty of going to the obstacle course area to help set up for the team's participation in the activity. Once in groups, teams will write a journal entry of what they expect to get out of these next few days. The teacher will also use the projector to show the Lego pieces they will be working on and have them sketch it and write the correct terminology. Teacher will also go over basic mathematical concepts, formulas, units of measurement that will needed. Students will access the necessary tools as needed. The NGSS will be addressed to the students. These are tricky concepts of energy transfer and use of electricity, heat, and light, but uses concrete examples through the Lego Robots Teacher will show the class one of the two obstacle courses they will be attempting at the end of the project. Q&A time. Lego manuals will be passed out and class will discuss how it's organized. Pair share reading will be used to describe how the instructions in the book will assist them in building the robot.
	The Lego kits will be distributed after a quick recap of the previous days activities is held. Students, now in groups, and with their assigned roles will begin the task of completing the robot.
	Robot building continues. Teacher will use clipboard assessment in order to determine if students are all engaged in the task, using content area vocabulary, and using the appropriate social interactions with peers.

Mathematics

	Mathematical terms will be reintroduced to class. Students will be given a handout with a mock obstacle course where they will use the appropriate tools (protractor, compass, ruler) to measure the distances, angles, perimeter, and area of the location. Once complete and recorded, students will be rotated onto the first of two obstacle courses where they will similarly measure and record observations about the actual course.
	Students will be introduced to the programing portion of the lesson. On the projector the students will be taught the icons that represent the movements and speed allocations for the robot. A quick jeopardy game on the different icons and their meaning (movement, speed, distance, rate, degrees, etc.), and students will then be assigned a

	laptop for the following day.
	Teacher will demonstrate the programming steps to the students using notecards with the icons drawn on them. (For example, a robot moving 5 paces forward, then tuning right and going an additional 3 paces will require 3 cards, one for each step). This direct-guided instruction will continue whole group until the independent work portion where students will be posed a series of procedures. Collabortably students will use TPR to l line up and hold the correct notecards in order.

Technology

	The laptop will be distributed to the groups. Teacher will first demonstrate how the programming works, reminding them that the notecards used in the previous exercises have helped them learn the computer method of programming. Students will be given a series of similar tasks to program for their robot. Instructions on how to transfer the program from computer to robot will be given, and then students will sue trial and error to complete assignment. For those moving ahead, teacher will now allow them to use what they know to program the robot for the first obstacle course. Students know the programming; they have measured the course, now it's a matter of revising their program and working together to make it successful. Struggling students will have additional teacher support with additional scaffolding.
	Students will primarily be working on programing their robot for the first obstacle course.
	Most student groups should complete the first obstacle course challenge. The second course is brought out. Students will not have seen it, and will have limited time to measure and prepare their programming and robot for completion in the following days.

Science

	Continued from the previous day.
	Challenge day for students to finish course in the lowest time possible. Teacher will also be interviewing students on their level of participation and knowledge in the class.
	Self-reflection and group surveys will be distributed. Robots and video clips of their challenges will be showcased. Revisit journal and conduct post survey.

As a reminder to teachers, after the basics, you are truly in the role of a facilitator. Allow students to work it through, make the mistakes, go back and start over. There is more than one way to design and construct the robot, and for the most part many ways to complete the programming portion. In just movement alone some students will tend to gravitate to the use of inches, where others will use *number of wheel rotations*, still others use degrees. What matters is their engagement and persistence to task.

Notes:

*As this lesson was being built and tried out, it seems more feasible to extend this to multiple days (weeks) due to the process of building and programming. Done at the end of the year where core content and assessments are complete would be advisable. Perhaps too during the holiday interval (where I completed this lesson) November-December.