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| **Title**  | Lego Thinking and Building |
| **Introduction**  | Statistics is the mathematics we use to collect, organize and interpret numerical data. It is used to describe and analyze data such as census statistics, governmental debt, unemployment rates, video game scores, new movie release profits to classroom and state mandated test scores. The ability to collect, organize and analyze data is essential. This project will allow mathematics students in grades 6-12 to develop an understanding of statistics use it to describe sets of data, model situations, and make knowledgeable predictions.This lesson utilizes data analysis of airplane production rates to make predictions and solve problems. The Lego Simulation discussed in this lesson will model production methodologies in cellular manufacturing from a business standpoint while incorporating mathematical goals of collecting, organizing, and interpreting data. The idea was originated from a simulation used to train employees at EMC2. EMC helps IT departments to store, manage, protect and analyze their information. |
| **Curriculum Alignment**  | Introduction to High School Math—Goal **3.01** Collect, organize, analyze, and display data (including scatter plots) to solve problems. **3.02** Approximate a line of best fit for a given scatter plot; explain the meaning of the line as it relates to the problem and make predictions.**3.03** Identify misuses of statistical and numerical data.Algebra 1--Goal **3.03** Create linear models for sets of data to solve problems.1. Interpret constants and coefficients in the context of the data.
2. Check the model for goodness-of-fit and use the model, where appropriate, to draw conclusions or make predictions.

**Algebra 2—Goal****2.04** Create and use best-fit mathematical models of linear, exponential, and quadratic functions to solve problems involving sets of data.1. Interpret the constants, coefficients, and bases in the context of the data.
2. Check the model for goodness-of-fit and use the model, where appropriate, to draw conclusions or make predictions.
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| **Learning Outcomes**  | **The learner will:*** Collect, organize, analyze, and display data to solve problems.
* Approximate a line of best fit for a given set of data; explain the meaning of the line as it relates to the problem and make predictions.
* Create linear models for sets of data to solve problems.
* Interpret constants and coefficients in the context of the data.

Check the model for goodness-of-fit and use the model, where appropriate, to draw conclusions or make predictions. |
| **Time Required and Location**  | To complete this lesson, two block (90 min) periods will be needed or four traditional (45 min) periods (approximately 180 mins). |
| **Materials Needed**  | * EMC Bio Worksheet or [5 min Video Link on EMC](http://www.screencast.com/t/EiLgSvHHR4)
* KWL Worksheet
* Multiple Sets of Legos
* Model Plane Diagram/Instructions
* Data Collection Worksheet
* Roles Descriptions
* Simulation Directions
* Graphing Calculator Instructions
* Day 2 Assignment Instructions
* Graph Paper
* Markers and Colored Pencils

Technology Resources* Graphing Calculators (At least one per Group)
* Overhead Calculator
* Data Projector (Optional)
* Stopwatch/Timers
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| **Participant Prior Knowledge**  | Students should have an understanding of the following prerequisites prior to beginning this lesson: * Identify and label axes on the coordinate plane.
* Graph an ordered pair to represent a point and identify the coordinates of a point graphed on the coordinate plane.
* Distinguish between independent and dependent variables.
* Write equations of lines in slope-intercept form and interpret the constant and coefficients in the problem.
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| **Facilitator Preparations**  | Part ATeacher should have copies of EMC Bio made and the KWL Worksheet. (Bio and worksheet are included in the RESOURCES/MATERIALS section.)* Teacher should have the desk set up into groups of 5 or 6 depending on the size of the class. Each seat should have an assigned task. If there are only 5 per group then only use 3 workers.

Inspector/RecorderBuilderBuilderSupplierBuilderBuilderTeacher should have a box of legos centered in the middle for each group. Teacher should have one set of directions on how to build the model plane at each group. (Provided in the RESOURCES/MATERIALS section.)Teacher should have a model plane built for each group to use as an example. (Sample provided in the RESOURCES/MATERIALS section.) Feel free to be creative and adapt the plane design to the grade level.Teacher should have copies made of table upon which students will record data collected throughout the simulation.Part BTeacher should have copies of graphing calculator instructions on entering data and finding linear regression models, one for each group. (Provided in the RESOURCES/MATERIALS section.)Teacher should have visible on the board or overhead instructions on organizing, graphing and interpreting data for students to follow. (Provided in the RESOURCES/MATERIALS section.) |
| **Activities**  | 1. Pass around a graphing calculator and ask students to enter information on their height and shoe size. If you are unfamiliar with entering data in the STAT menu, see the graphing calculator instructions in the RESOURCES/MATERIALS section.

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| L1 | L2 |
| Height | Shoe Size |

1. While the students are passing the calculator around and entering information, begin a discussion with the students by asking them a series of questions about relationships between variables. Have students explain why they chose yes or no.
* Can you estimate a person’s shoe size based on their height?
* Can you predict you test average based on the number of assignments completed?
* Can you predict the unemployment rate in the US if you know the population?
* Can you predict the suspension rate of a school if you know the cost of lunch for that school?

*Note: These questions are used to stimulate conversation and discourse amongst the students while the data is being entered into the graphing calculator.*1. After the students have finished entering data into the calculator, project the scatter plot of the data onto the overhead calculator or the data projector. If you are unfamiliar with entering data in the STAT menu, see the graphing calculator instructions in the RESOURCES/MATERIALS section.
2. Ask the students to discuss the graph and any observations they see or what conclusions can they make.
3. Next introduce scatter plots to the students by giving the following definition of a scatter plot:
* A scatter plot is a graph that relates two groups of data. To make a scatter plot, plot the two groups of data as ordered pairs. Ask the students why the scatter plot showing their heights and shoe sizes are only located in the 1st quadrant? Answer: Most scatter plots are in the first quadrant of a coordinate plane, because real-life data is normally represented by positive numbers.
1. Introduce the students to correlation by asking what trends or parents do you notice in the height/shoe size data? The students should have noticed that as the heights are increasing, the shoe sizes are also increasing. Explain this to students that this represents a positive correlation. Define the term correlation and positive correlation for students and ask them to give other examples of positive correlations. Be sure to emphasize that if two variables are correlated, it is not necessarily true that change in one variable causes a change in the other.
* Correlation shows the type of relationship that exist between sets of data.
* Positive Correlation As one set of data increases, the other set of data also increases.
1. Ask the students to give an example of a negative correlation. Define the term negative correlation.
* Negative Correlation As one set of data decreases, the other set of data decreases.
1. Ask the students how they would categorize the relationship between price of a cheeseburger and the amount of time people stand in line at the grocery store. Student should recognize that there is no relationship between the two variables. Define the term no correlation.
* NO Correlation Two sets of data do not relate to each other – one set has nothing to do with the other.
1. Tell the students that you can use scatter plots to look for trends and patterns in data. Present the three scatter plots below to show the types of relationships two sets of data may have.

2012-03-01_0105.png1. Divide the students into pre-arranged groups if they are not already in their groups.
2. Explain to student that statistics is used in businesses to find trends in sales and profits and helps them make predictions when making future decisions. Tell students that one company in particular that uses data to drive decisions is EMC. Play the brief video on EMC to give students background on the company or pass out the worksheet and have the students read a bio in their groups about EMC. After they have watched the video or read the bio, have them do a quick KWL (I know, I want to know, I learned) within their groups. After the students have completed the activity, tell the students today their groups of 5 or 6 students will represent a manufacturing plant that makes model airplanes using cellular manufacturing similar to EMC. Define cellular manufacturing to explain why the student desk are arranged in rectangles.
* Cellular Manufacturing refers to a manufacturing system wherein the equipment and workstations are arranged in an efficient sequence that allows a continuous and smooth movement of inventories and materials to produce products from start to finish in a single process flow, while incurring minimal transport or waiting time, or any delay for that matter.
1. Provide each student with a model airplane, a set of legos, directions for building sample model plane and a data collection worksheet.
2. Explain to the students their individual roles based on where they are sitting. A description of the roles are included in **RESOURCES/MATERIALS**.
3. Read the simulation instructions to the students and explain that you will be timing them and running the plant. They must be attentive to any orders or requests that you have made.
4. Run the airplane simulation using the instructions provided in **RESOURCES/MATERIALS**.

Part B1. Students continue in their groups. Today they will create linear models from the data collected today and use the models to predict the number of airplanes defective if a certain amount is produced. Be sure that all students have their data tables filled out, a graphing calculator and worksheet B.
2. After the students have completed the worksheet, ask them to present their answers to the “Check for Understanding” to the class.
3. After each group has presented, has a class discussion on the data, their findings and anything observations made.

Sample Questions to Ask the Class:* *Begin by stating that to students “you began the predictions with information about total models predicted and total defects. As you worked on the problems of this investigation, what does the slope tell you or suggest about the about the number of defective planes as the total produced increases or decreases? What does the y-intercept suggest?*
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| **Assessment**  | Students previously compared total planes produced and total defective planes to create a linear model. To assess student understanding, provide each student with a sample data set to create a linear model. Websites have been provided if you need assistance finding data sets. Student should create scatter plots using the provided table, determine the correlation and create a line of best-fit. Students will also need to describe the affect of the slope and y-intercept on the data and their predictions.**NOTE:** You are looking for students to understand that the slope represents the estimated change in Y, the dependent variable, when X, the independent variable, increases by one unit. The y- intercept represents the estimated value of Y when X equals zero. Be careful with the interpretation of the y-intercept. Sometimes when the value X=0 we may get an impossible solution. For example, if you refer back to the height versus shoe size example. There is no such thing as a person having a height of zero. |
| **Critical Vocabulary**  |

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| Scatter Plot | A graph that relates two groups of data. |
| Dependent Variable | The output values. |
| Independent Variable | The input values. |
| Line of Best Fit | The trend line that shows the relationship between two sets of data most accurately. |
| Correlation | shows the type of relationship that exist between sets of data. |
| Negative Correlation | one set of data decreases, the other set of data decreases. |
| No Correlation | Two sets of data do not relate to each other – one set has nothing to do with the other. |
| Positive Correlation | As one set of data increases, the other set of data also increases. |
| Slope | The ratio of the vertical change to the horizontal change; The relationship between two quantities that are changing (rate of change). |
| Y-intercept | the y-coordinate of the point where a line crosses the y-axis. |
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| Cellular Manufacturing (CM) | Refers to a manufacturing system wherein the equipment and workstations are arranged in an efficient sequence that allows a continuous and smooth movement of inventories and materials to produce products from start to finish in a single process flow, while incurring minimal transport or waiting time, or any delay for that matter.  |
| Rework:   | Fixing mistakes that were made on a product |
| Scrap:  | When a product is so broken or screwed up we can’t fix them we must get rid of it |
| WIP:  | Work in process; a count of all the products we have in different stages of being built |
| Cycle Time:  | The amount of time it takes to complete the activities from start to finish |

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| **Modifications**  | Part A* The data entry component can be modified to using more age relevant data such as amount of television watching and the amount of books read per much, to more complex examples such as comparing population rates and percentage of infectious diseases. Regardless of what data you choose, they each can be created in advance to save time.
* As you group the students, if you have ESL students it may be helpful to provide the video as an alternative to reading the bios.
* When assigning groups, if you have students with learning disabilities provide them with a more hands role such as stations 2,3, 5, and 6 that require them to build the airplanes.
* If legos are not available, use this site to find similar activities that focus on the lean concept and allow you to collect data: <http://www.leansimulations.org/p/huge-list-of-free-lean-games-and-other.html>

Have students find their own sets of data or perform a survey to collect data. Have them create a scatter plot a linear model. Sample data is provided in the **RESOURCES/MATERIALS** section. Other websites include: <http://data.bls.gov/cgi-bin/surveymost?ap>  |
| **Alternative Assessments**  | * If time is not permitted or access to websites are not available, have students complete the worksheet provided in the **RESOURCES/MATERIALS** section. You can also use this assessment in place of using the available data sets.
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| **References** | This section contains a consistent and properly annotated list of publications related to the research focus for this module.  |
| **Supplemental Information**  |

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| Topic: | Useful Websites: |
| Interactive Site to Model Correlation | <http://staff.argyll.epsb.ca/jreed/math9/strand4/scatterPlot.htm> |
| How to Make Scatter Plots using Graphing Calculator | <http://www.youtube.com/watch?v=BdUJxrqpdUA><http://www.tc3.edu/instruct/sbrown/ti83/regress.htm><http://mathbits.com/mathbits/tisection/statistics1/linefit.htm> |
| How to Make Scatter Plots using Microsoft Excel | <http://www.physics.purdue.edu/resources/excel_straight_line/><http://www.youtube.com/watch?v=RgxNq4Hhz6k><http://www.internet4classrooms.com/excel_scatter.htm> |
| How to Create Lines of Best-Fit using Graphing Calculator | <http://www.tc3.edu/instruct/sbrown/ti83/regress.htm><http://mathbits.com/mathbits/tisection/statistics1/linefit.htm> |
| How to Create Lines of Best-Fit using Microsoft Excel | <http://www.physics.purdue.edu/resources/excel_straight_line/><http://www.youtube.com/watch?v=RgxNq4Hhz6k><http://www.internet4classrooms.com/excel_scatter.htm> |
| Additional Activities to Practice Scatter Plots and Lines of Best-Fit | <http://education.ti.com/educationportal/sites/US/nonProductSingle/activitybook_forensics.html><http://mainland.cctt.org/mathsummer/JosephBond/LineofBestFit/line_std.htm> |
| Information on EMC2   | <http://www.emc.com/> |
| Lean Simulation Activities if Legos not available | http://www.leansimulations.org/p/huge-list-of-free-lean-games-and-other.html |

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| **Comments**  | **EMC2 Biography--Corporate Profile**EMC is a global leader in enabling businesses and service providers to transform their operations and deliver Information Technology as a service. Fundamental to this transformation is cloud computing. Through innovative products and services, EMC accelerates the journey to cloud computing, helping IT departments to store, manage, protect and analyze their most valuable asset — information — in a more agile, trusted and cost-efficient way.**Broad Range of Customers**EMC works with organizations around the world, in every industry, in the public and private sectors, and of every size, from startups to the Fortune Global 500. Our customers include banks and other financial services firms, manufacturers, healthcare and life sciences organizations, Internet service and telecommunications providers, airlines and transportation companies, educational institutions, and public-sector agencies. EMC also provides technology, products, and services to consumers in more than 100 countries.**Strong Leadership Record**Our differentiated value stems from our sustained and substantial investment in research and development, a cumulative investment of approximately $10.5 billion from 2003-2010. To strengthen our core business and extend our market to new areas, EMC has invested $14 billion in acquisitions over the same period and has integrated 36 technology companies since 2006 alone. EMC is supported by thousands of technical R&D employees around the globe, the industry's broadest portfolio of systems, software, and services, our ability to create total integrated solutions, and our commitment to delivering the best Total Customer Experience in this or any industry. We operate R&D centers in Belgium, Brazil, China, France, Ireland, India, Israel, the Netherlands, Russia, Singapore, and the U.S., and manufacturing facilities in the U.S. and Ireland. We hold the most stringent quality management certification from the International Organization for Standardization (ISO 9001), and our manufacturing operations hold an MRP II Class A certification. EMC ranks152 in the Fortune 500 based on total consolidated revenue of $17 billion in 2010, the largest revenue year in EMC's 30+ year history.**Global Presence**EMC employs approximately 48,500 people worldwide. We are represented by approximately 400 sales offices and scores of partners in more than 80 countries around the world. We have the world's largest sales and service force focused on information infrastructure, and we work closely with a global network of technology, outsourcing, systems integration, service, and distribution partners. We are committed to acting in a socially and environmentally responsible manner and to being an attentive and thoughtful neighbor in our local and global communities. We are a publicly traded company, listed on the New York Stock Exchange under the symbol EMC, and are a component of the S&P 500 Index.Link to 5-Minute Video on EMC<http://www.screencast.com/t/EiLgSvHHR4> |
| **Author Info**  | Kenan FellowMy name is Lessie Anderson and I teach Math at Knightdale High School in Wake County Public Schools System. I have taught for 11 years. I have a BA in Mathematics and a MAT both from UNC-Chapel Hill as well as an MBA from East Carolina University. I also received my National Board Certified Teacher in 2006. This project was developed as a result of my externship with EMC2. Collection of data and its analysis is a critical skill needed for students to be competitive and a new requirement for the new Common Core Standards. There are several lessons that can be pulled from the collection of data. Moreover, the simulation allows students to see how real-world applications relate to classroom knowledge. Mentors***Jane Woodall***Jane is a graduate of NC State University with a BS in Mathematics and graduate studies in Industrial Engineering. She has been working at EMC Corporation in the Apex, NC Manufacturing facility since 1985. She started her career with EMC (formerly Data General) as a Process Engineer, and is currently in the role of Customer Quality Manager. In this role, Jane interfaces with EMC’s customers and customer service organization to resolve any manufacturing related issues found in the field. She is also involved in management of the site’s ISO 9001, ISO 14001, and OHSAS 18001 programs. However, her primary responsibility is driving improvements in EMC’s processes through EMC’s Lean Six Sigma Program. Jane not only leads Lean Six Sigma initiatives/project teams for the corporation, but she is active in mentoring less experienced team leaders and delivering training classes. She is an EMC Certified Lean Six Sigma Blackbelt.***Leeann Parrott***Leeann is a graduate of West Georgia College with a BS in Sociology with an emphasis in Criminology Justice. She is an EMC Certified Lean Six Sigma Blackbelt. She is an Experienced Project Manager focusing on continuous improvement via teams using a variety of tools & techniques. Leeann also has experience with both manufacturing & non-manufacturing process improvements. She has 50+ successfully projects completed. Her background also includes Lean Auditor & Program Manager for QMS, EMS, & OHSMS in Apex, Qualified EMC instructor for several Lean Six Sigma courses; qualified mentor and has served in various technical & management roles in computer manufacturing.  |