**IME Culminating Activity**

**Objective**

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| **Objectives**  1.) Demonstrate understanding of Just-In-Time Manufacturing, Facilities Layout Design, and Design for Manufacturability through completion of this activity. |

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| **Skill Level:** This activity is targeted for middle school age and knowledge level. | **Prep time:** 1-2 hours  **Activity time:** Approximately 2-4 hours |

**Materials**

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| * 5 LEGO Creator kits #6912 per group of 5 students. * 1 printout of background story for each group of 5 students |

**Standards**

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| **Disciplinary Core Idea:** ETS1.C: Optimizing the Design Solution  **Performance Expectations:**  MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.  MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved. | |
| **Practices** Asking questions / defining problems Developing / using models Planning / carrying out investigations Analyzing / interpreting data Math / computational thinking Constructing explanations / design solutions Engaging in argument from evidence Obtaining / evaluate / communicate | **Crosscutting Concepts**  Short/Long term Consequences  Positive/Negative Consequences  Society Driven Technology Systems and system models |

**Background Information**

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| Background Story:  mindstorm.jpg  *LEGO Mindstorm Inc.* is a manufacturing company that builds the latest and greatest products out of LEGO components. The company is known far and wide as a leader in new product development and is a technological leader in manufacturing. They pride themselves on their use of Industrial and Manufacturing Engineering concepts to produce the highest quality products, and to do so in a timely manner.  Recently *LEGO Mindstorm* has been having trouble living up to their high standards. They have taken on several new projects for customers that they are having a struggle in developing and producing. What they have discovered is that the products are too complex to make in a timely fashion, and the cost to manufacture them is too high. *LEGO Mindstorm* is having trouble making a profit on these products.  In order to remedy the situation, and restore quality and profitability to the company, *LEGO Mindstorm* has turned to your group to use your industrial and manufacturing engineering experience and knowledge to improve the new products development. You will look at the whole production of your product and see what areas there are for improvement. Once you have a plan to improve the product design or manufacturing you will implement this improvement and compare and contrast the results. Your goal is to increase the amount of money that *LEGO Mindstorm* can make in the given amount of time. The best way to accomplish this goal is to make the products as simple as possible in order to reduce cost and manufacturing time.  legoteam.jpg |

**Procedure**

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| 1. Get students into groups of 4 or 5 students.  2. Hand out materials listed above to each group.  a. Each group should receive 5 Lego kits. (unless there are only 4 people, then 4 kits are acceptable.  3. The teacher is to assign each group to make either the helicopter or boat.  a. The instructions for each product are provided along with this file.  b. The product chosen for each group is built by all members of the group with all kits.  4. The instructions are divided into 4 workstations (see provided kit instructions)  a. The materials for each workstation is placed in containers ahead of time to speed up the building process.  b. Each workstation has its own set of unique instructions for both the helicopter and the boat.  5. The layout of the workstations should be non-sequential or non-ideal (an example of the initial layout is provided below).  Initial layout for CA.JPG  6. Each student is assigned a workstation. For groups of 5 the extra student should observe the process while trying to identify the bottleneck or areas for process improvement by taking notes on the provided activity sheet.  7. The students should build their assigned products for 30 minutes according to the initial instructions. By the end of this time, at least one completed product should be through the line. If at least one product is not completed at the end of 30 minutes the time can be extended until one product is finished.  8. After the building time is over, students should note how many products were completed and how much Work In Process (WIP) is between each workstation.  9. Each portion of WIP that is sitting in front of a workstation 2, 3 and 4 costs the company $50. (each product that has been started but is waiting to be worked on is considered WIP for this activity). Workstation 1 has no WIP. To calculate the WIP expense, multiply the number of WIP in line by $50  10. The selling price of the product ($1000 for the boat, $1200 for the helicopter) should be multiplied by the number of completed products made. This is the company income. The WIP expense should be subtracted from the company income. This is the actual amount of money made during this time period. The point of this is to illustrate that the WIP that has been started but not completed is reducing the amount of profit.  11. Record the total amount of money made by the company for run # 1.  12. Together the group should observe the finished product and identify parts that could be reduced to save money.  13. The students should remove the parts that are not needed for the functionality of the product. The basic product must be the same, but some parts can be redesigned or have non-necessary parts removed.  14. Each part that is removed is assigned a cost by the color of the Lego. The chart for the prices of each color of Lego is listed below. Add up this cost for all of the parts that were removed. This is the removed cost. The extra person that was not assigned a workstation should be assigned to adding up the value for the removed pieces.    15. The total removed cost should be divided by the original product manufactured cost and then multiplied by 100. This is the percentage of cost reduction between the original product and simplified product.  16. Students can compare between groups their reduction percentage and what their simplified product looks like.  17. Once all of the simplification is done to the product (as decided by the group), then the Lego products should be taken apart and organized as they were in the beginning of the activity to reset the factory. Additionally the students should cross out the pieces that were removed from the design on the workstation instruction sheets.  18. For the second run of this activity, the workstations should be reorganized as the students see fit. They can be in sequential order for better product flow. Students may also wish to divide the workstation tasks up more evenly to eliminate any bottleneck operations.  19. Students should identify that this run should be a pull system. When the last workstation needs work, the previous workstation creates for them, and so on backward down the line. The product is being pulled from the end of the line, rather than pushed from the beginning. This should reduce the amount of WIP in the line. Students should arrive at this conclusion from a previous lesson, but may need to be reminded of this method of production.  20. Build the modified product in a production line for the same amount of time as before (30 minutes).  21. At the end of the time, count and observe how many products were produced. There should be more products finished because they should be simpler and easier to build now.  22. Add up the cost of the WIP as before (# of WIP multiplied by $50) and subtract from the income made from the finished products (income is the number of completed products multiplied by the selling price). This is how much money the company made during this time period. Record this result for run # 2  23. Take all of the products apart and return ALL pieces to the original containers. Cleanup.  24. Discuss and share:   * Was the goal met? * Was more money made by the Lego Mindstorms during the second production run? * Were more products made because the products were simpler or because the workstations were in a better order? * Did the product manufactured in the second run cost less? How much? * Would the CEO of Lego Mindstorm be satisfied with your groups cost saving efforts?   Allow a pair share opportunity after students think of responses to these questions. Allow all the helicopter groups to share their product redesigns and their total profit for each run. Ask that they share what improvements they made and why. Follow up by asking what future modifications could be made to make their factory even better. Allow the boat groups to conduct the same discussions within their groups.  Lego Helicopter   * Original Manufacturing cost: $1000 * Selling price: $1200   Lego Boat   * Original Manufacturing cost: $800 * Selling price: $1000 |

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| **Elaborate** |
| 1. What did you learn from this activity? |

**Resources**

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| **Additional Resources:**    Provided product redesign solutions  Provided activity sheet  Provided activity worksheet and worksheet key  Provided boat and helicopter workstation instructions |