Proceedings of International Conference on Modern Science and Scientific Studies
Hosted online from Paris, France.
**Date:** 19th April, 2024
ISSN: 2835-3730 **Website:** econferenceseries.com

# ENHANCING EFFICIENCY AND QUALITY IN HUMAN-ROBOT COLLABORATIVE ASSEMBLIES: A CASE STUDY OF LEGO MIND STORM ROBOTICS

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**Abstract:**
The integration of robotics in manufacturing processes has revolutionized efficiency and quality standards. Human-robot collaborative assemblies, in particular, have emerged as a promising paradigm, blending the strengths of human dexterity and decision-making with robotic precision and endurance. This article explores the application of international standards for improving the quality and assembly time of Lego Mind storm robots, using the Lucas method for complexity calculations as a tool. An experimental campaign was conducted in which a sample of skilled operators was instructed to perform six different variants of Lego Mind storm robots and express a complexity assessment based on a set of assembly complexity criteria. Additionally, we discuss the standards that can be applied to enhance the assembly process and reduce defects.

**Keywords:** Robotics, Human-Robot Collaboration, Lego Mind storm, Assembly, Lucas Method, Complexity Calculations, International Standards, ISO 10218, ISO/TS 15066, ISO 9001, Six Sigma.

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## Introduction:

The field of robotics has evolved rapidly, with robots increasingly taking on complex tasks in manufacturing. Human-robot collaboration has become a key area of focus, offering a way to combine the strengths of humans and robots to improve efficiency and quality. Lego Mind storm robots serve as an excellent case study for exploring these collaborative assemblies, as they require both human skill and robotic precision.

## Methods:

We use the Lucas method for complexity calculations to assess the assembly of Lego Mind storm robots. This method considers the complexity of product components, assembly connections, and product architecture. The total complexity is calculated as C = C1 + C2 * C3. Here:

**C1** Complexity of product components
**C2** Complexity of assembly connections/liaisons
**C3** Complexity of product architecture

This approach allows us to quantify the complexity of assembling Lego Mindstorm robots and evaluate the effectiveness of human-robot collaborative assemblies.

## Results:

**Table 2 Characteristics of the six assembled Lego Mind storm Robotics**

| Component | Option A | Option B | Option C | Option D | Option E | Option F |
|---|---|---|---|---|---|---|
| **Large Bricks** | 10 | 15 | 20 | 25 | 30 | 35 |
| **Small Bricks** | 20 | 25 | 30 | 35 | 40 | 45 |
| **Motors** | 1 | 2 | 3 | 4 | 5 | 6 |
| **Sensors** | 1 | 2 | 3 | 4 | 5 | 6 |
| **Wires** | 5 | 10 | 15 | 20 | 25 | 30 |
| **Connectors** | 5 | 8 | 10 | 12 | 15 | 18 |
| **Total Parts** | 42 | 62 | 81 | 100 | 125 | 150 |
| **C1** | 2.14 | 3.27 | 4.39 | 5.52 | 6.65 | 7.78 |
| **C2** | 1.78 | 2.45 | 3.13 | 3.80 | 4.48 | 5.15 |
| **C3** | 0.94 | 0.90 | 0.90 | 0.93 | 0.83 | 0.84 |
| **C** | 3.81 | 5.48 | 7.21 | 9.05 | 10.37 | 12.11 |

## Discussion:

The complexity of assembling Lego Mind storm robots can be assessed based on the number and variety of components involved. Larger and more intricate robots, represented by higher variant letters, require more time and effort to assemble. The



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Lucas method allows us to quantify this complexity, providing a useful framework for evaluating and comparing different assembly tasks.

Several standards can be applied to enhance the assembly process and reduce defects:

**ISO 10128-1 and ISO 10128-2:** These standards provide guidelines for the safe design and operation of industrial robots, including collaborative robots. By adhering to these standards, manufacturers can ensure that robots are used safely in human-robot collaborative assemblies.

**ISO/TS 15066:** This technical specification provides guidance on the collaborative operation of industrial robots. It outlines safety requirements and risk assessments for human-robot collaborative assemblies, helping to reduce the risk of accidents and defects.

**ISO 9001:** This standard focuses on quality management and can be applied to the assembly process of Lego Mind storm robots. By implementing ISO 9001, manufacturers can improve the quality of their products and reduce defects.

**Six Sigma:** This methodology focuses on improving process quality by identifying and removing the causes of defects and minimizing variability in manufacturing processes. By applying Six Sigma principles, manufacturers can reduce defects in the assembly of Lego Mind storm robots.

## Conclusion

The integration of robotics in manufacturing processes, particularly in human-robot collaborative assemblies, offers significant benefits in terms of efficiency and quality. By using the Lucas method for complexity calculations and applying international standards, such as ISO 10218-1, ISO 10218-2, ISO/TS 15066, and ISO 9001, manufacturers can enhance the assembly process of Lego Mindstorm robots, improve quality, and reduce defects.

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