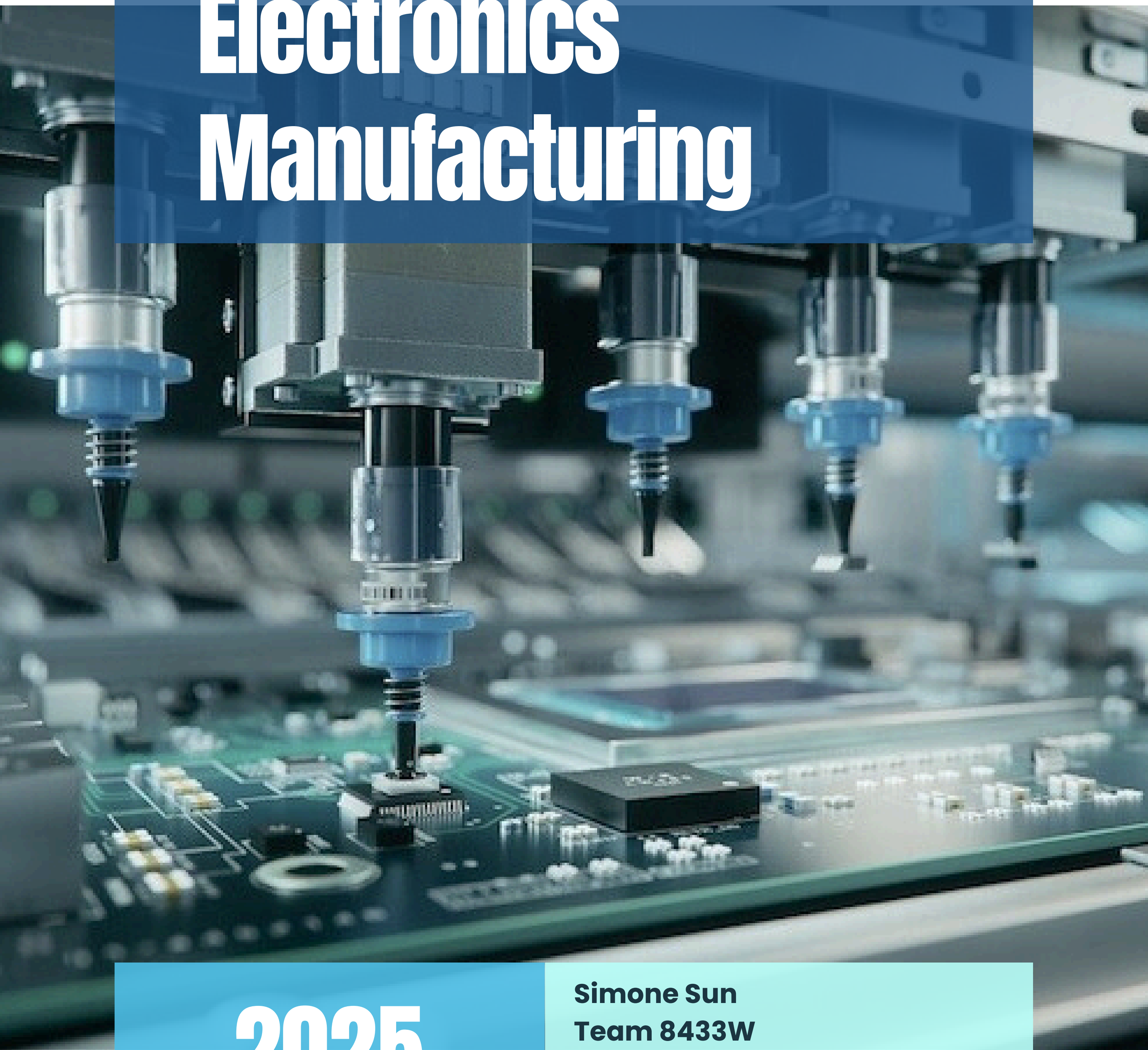
# Automating Quality Control in Electronics Manufacturing



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Workforce Readiness Challenge

# Electronics Manufacturing Industry

Electronics manufacturing is the process of transforming design concepts into concrete electronic products. In a world where electricity permeates virtually every field in society, electronics manufacturers have a massive responsibility: to ensure the highest quality of goods they provide in order to maintain not just satisfaction in their customer base, but often physical and informational safety of billions of people.

A series of interconnected stages of electronics manufacturing include:

### 1 Designing and Prototyping

Conceptualizing the product, developing a blueprints using CAD(Computer-Aided Design) tools, and creating a prototype for testing and revision.

### 2 Component sourcing

Obtaining electronic components, such as circuits, resistors, capacitors and connectors, from suppliers using ERP(Enterprise Resource Planning) to manage inventory and suppliers.

### 3 PCB Fabrication

Making print circuitry images onto the inner layer cores of the circuit board for more accurate assembly later.

### 4 PCB Assembly

Placing the components onto the board by using SMT(Surface Mount Technology) or THT(Through-Hole Technology). SMT is attaching components directly onto the surface while THT is placing components through pre-drilled holes in the board.

### 5 Quality Control

Consulting the production quality control checklist, inspecting, testing, and quality assuring at different stages to ensure products meet requirements.

### 6 Enclosure/Final Assembly

Joining other external components(e.g. displays, buttons, connectors) and providing physical protection(e.g. plastic, metal) onto the product.

### 7 Final Quality Control/Testing

Using various tests, including functional testing, environmental testing, and reliability testing, to verify the functionality, performance, and adherence of the product meets the quality standards

### 8 Packaging and Shipping

Wrapping and casing the product with packaging materials to prevent damages to the product.

# Quality Control

Quality control is important in electronics manufacturing because of its effects on not only the quality of products but also the company's reputation and cost of production. Defects reduce the utility of products, causing damage to the fame of the company. Additionally, quality control helps reduce costs of production by identifying issues in the manufacturing process.

As seen on page 01, quality control in an electronics manufacturing production process typically appears in two phases: before and after the product is fully assembled. However, the process of quality control itself can be further broken down into more steps:

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I. **Establish Controls:** Define a standardized set of controls to which product and service quality are to conform.

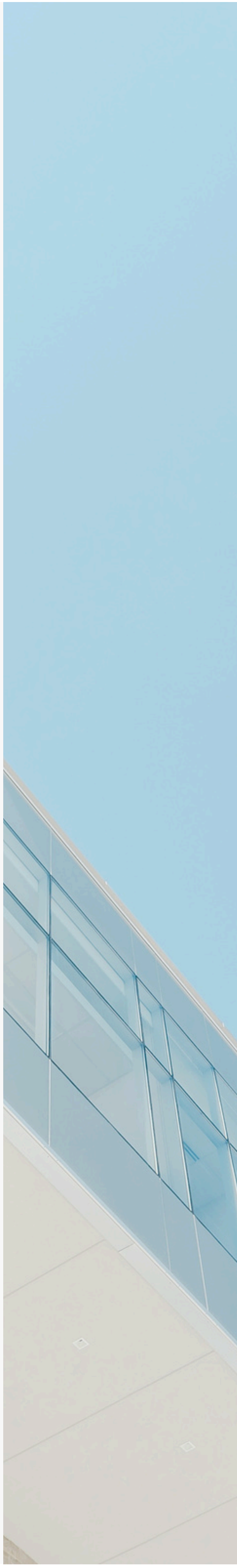
II. **Test and Check the Product/Service:** Test the product as a whole and the separate modules to make sure to cover as many scenarios as possible.

III. **Analyze Variance:** Analyze the difference between the ideal set controls and the actual quality of the product in real life.

IV. **Check and Define Limits:** Check the tolerance levels, which is whether or not variances are within statistical limits, and document them down

V. **Corrective Decisioning:** If the variances exceeds the tolerance limits, then a corrective action is taken to improve the quality

VI. **Benchmark and Feedback:** Establish procedures so that the variances do not happen again



# Demands and Challenges

### DEMANDS: COMPANIES

- Reduce the excessive costs
- Increase the accuracy of the failure detection
- Incorporate and widespread the automation
- Establish eco-friendly procedures

### DEMANDS: EMPLOYEES

- Upskilling in automation
- Adapt to the smart environment
- Reassurance of security of job position
- Salary increase due to transition from unskilled to skilled workers

### DEMANDS: CUSTOMERS

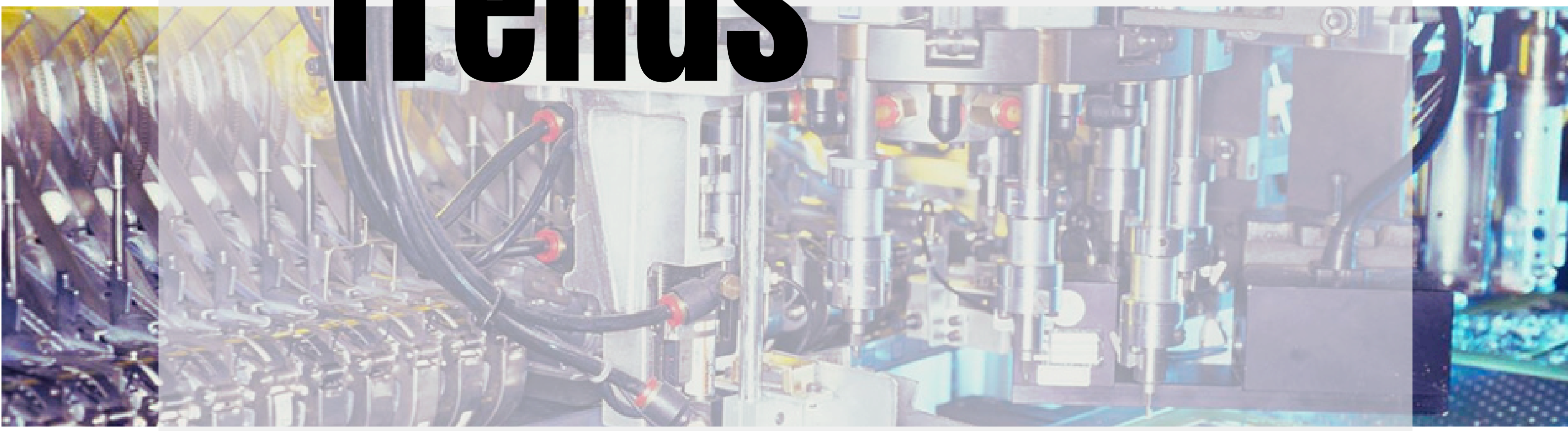
- Products with high quality and no defect
- Fast delivery
- Reasonable cost depending on the degree of customization

## THE CHALLENGE

In the past, workers manually conducted inspections and ensured that products met the requirements, demanding a high level of repetitiveness and accuracy simultaneously. This procedure has led to the industry being strongly labor-intensive and time-consuming, as the workers had to physically monitor production lines, requiring a considerable amount of workers and long time periods.

With the advent of robotics and improved models and their increasing integration into the electronics manufacturing industry's quality control processes, are capable of yielding more precise results within a short period of time. However, as the needs of the job shifted from simply being able to examine and check for errors in the product to being able to manage, operate, and maintain more complicated systems, t<u>he barrier soon became unbridgeable for many employees as they did not have the capability to perform these new and technically advanced jobs, leading to job loss and reduced workforce adaptability.</u>

# Trends



## 01 Internet of Things(IoT)

A variety of IoT-enabled devices are connected to the internet to revolutionize the integrated system by incorporating sensors and connectivity into machines to provide real-time insights, improve efficiency, and enable predictive maintenance.

## 02 Artificial Intelligence(AI)

The simulation of human intelligence by computer systems used to detect and reduce manufacturing defects and enhance product design.

## 03 Big Data Analytics

The tools and methods of collecting, processing, and deriving patterns from high-volume and high-velocity data sets to identify hidden trends and discover root-cause quality issues.

## 04 Computer Vision(CV)

Advanced image processing techniques used to automate visual inspection using high-resolution cameras combined with machine learning algorithms to analyze product images with precision and detect defects at smaller scales.

## 05 5G

The fifth generation of wireless cellular technology allows data to transfer faster and more reliably from machine to machine, strengthening the communication between them.

## 06 Augmented&Virtual Reality(AR&VR)

AR is the overlay of virtual items onto real world objects while VR is a complete virtual environment. They provide immersive training experience for the employees practically without real-life risks by simulating possible scenarios.

These trends collectively drive the advancement of electronics manufacturing into the new era of Industry 4.0, focusing on technological innovation.

# Models

**Key Inquiry:** How to transit into the new automated process without the workers being outpaced?

Several models can be used to address this by providing structured frameworks for changes, implementing automation, and ensuring workforce adaptation. The following models have been selected:

## Kotter's 8-Step Change Model

This model was chosen because it effectively helps leaders to implement organizational change.

1. Urgency: develop an urgency for change by communicating potential threats and opportunities.
2. Powerful Coalition: form a coalition of influential people.
3. Vision for Change: create a plan for the specific change in the future development of the company.
4. Communication: talk about the vision frequently and address people's concerns.
5. Remove Obstacles: Identify people who are resisting the change and help them see what's needed.
6. Short-Term Wins: show workers a taste of victory early in the process.
7. Build on the Change: Set stepwise goals every time to keep the momentum of victory.
8. Anchor the Changes: Often talk about the progress and success stories due to the changes made and recognize the key members in the coalition.

## Business Process Automation

This model was chosen because it transforms repetitive manual work into streamlined procedures with minimal cost.

1. Analysis: Examine the current pros and cons of the system to set up goals of automation.
2. Integration: Choose suitable technologies and put them into use.
3. Implementation: Combine the technologies with the enterprise system and third-party tools.
4. Maintenance and Support: Look for inefficiencies in the established system.

## Industrial Operations X

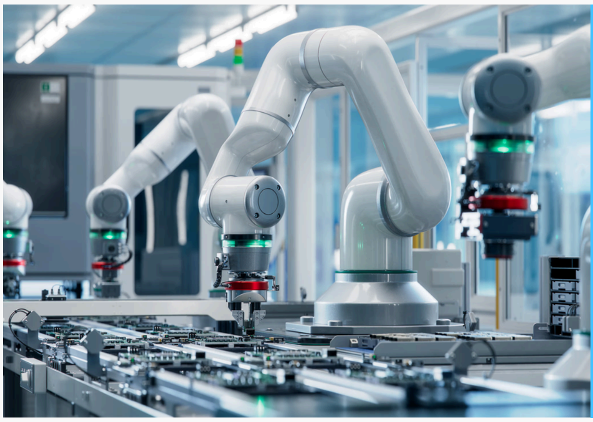
This model was chosen because it is technologically adaptive and primarily focus on the interactions between human and technologies.

- Software-Defined Automation: replacing hardware-based automation devices to software-defined automation for easier updates and management.
- Data-Driven Production: using AI and data analytics to move from hard-coded production to data-driven production for more flexibility.
- Modular Operations: splitting the operations into smaller portions with less complexity and more adaptability.
- Industrial Ecosystem: enabling an open ecosystem with interoperability between multiple vendors for all levels and requirements of industrial operations.

# Blended Automated Solution

## Collective Automated Solution

Although the models mentioned above are effective, they require some alteration to better align with our needs. By "blending" and modifying the models, a more detailed and optimal collective solution can be implemented to prevent the workers from being eclipsed. The following blended automation model aims to provide the most comprehensive strategic framework according to which an employee adaptation program can be implemented (this program is detailed on page 9).



### 01: Analysis

- Analyze the process of the current system to examine the pros and cons
- Observe how employees feel about changes
- Pinpoint the goals and reasons of automation

01

### 02: Powerful Coalition

- Form a coalition of impactful people whose power comes from a diversity of sources(e.g. job title, status, expertise, and political importance).
- Ask for an emotional commitment from these key people to the rest of the company.
- Develop a sense of urgency for change through the communication of potential threats and opportunities by the coalition members, customers, outside stakeholders and industry people
- Gather ideas and solutions from the coalition members to create a plan for the specific change in the future development of the industry or company and come up with a strategy to implement the plan.

02

### 03: Communication

- Talk about the vision frequently
- Address peoples' concerns and anxieties openly and honestly.

03

## 04: Implementation

- Choose suitable technologies and put them into use
- Extensive testing to ensure that the systems are performing as expected
- Such technologies include software-defined automation, data-driven production, modular operations.

## 05: Integration

- Combine the technologies mentioned above with the enterprise systems and third-party tools
- Integrate data from various sources for functionality and simplification

## 06: Remove Obstacles

- Align vision with organizational structure, job descriptions, and performance and compensation systems
- Acknowledge and reward people for making change happen.
- Identify people who are resisting the change, and help them see what's needed. If the problem cannot be solved, take action to quickly remove barriers (human or otherwise).

## 07: Short-Term Wins

- Show workers a taste of victory early in the change process.
- Start with projects that are the cheapest or have the most agreements along the employees to minimize the critiques and opportunity costs

## 08: Build on Change

- Analyze what was done correctly and what was not after each trial to ensure continuous improvement
- Set stepwise goals every time to keep the momentum of victory
- Expand the usage of automation through industrial ecosystem

## 09: Maintenance and Enhance

- Look for bottlenecks and inefficiencies in the established system
- Unceasingly update advanced duties as the designed structure is put into use
- Often talk about the progress and success stories due to the changes made
- Publicly recognize key members of change coalition so that the rest of members of the industry remember their contributions

# Employee Training Plan

The employee training plan consists of the following key steps:

## I. Investigate the Skills the Employees Already Possess

Survey and interview the employees on their education level and expertise to tailor training goals.

## II. Training Objectives

Because the workers were originally working in the same environment and they have already trained their soft skills, the training program will be specifically targeting the mechanical aspect.

- Learning the technical skills to operate, monitor, and troubleshoot automated machinery
- Working with robotics, IoT-enabled systems, and quality control software (such as QMS systems) from hands-on experience
- Understanding methods to interpret data provided from the sensors
- Minimizing the time spent in quality control
- Increasing the efficiency of the cost spent
- Achieving certificates or diplomas from different programs (Apprenticeship Program/Advanced Manufacturing Certification Program/Technical Colleges/Community College)

# III. Types of Training

## a. Online Courses

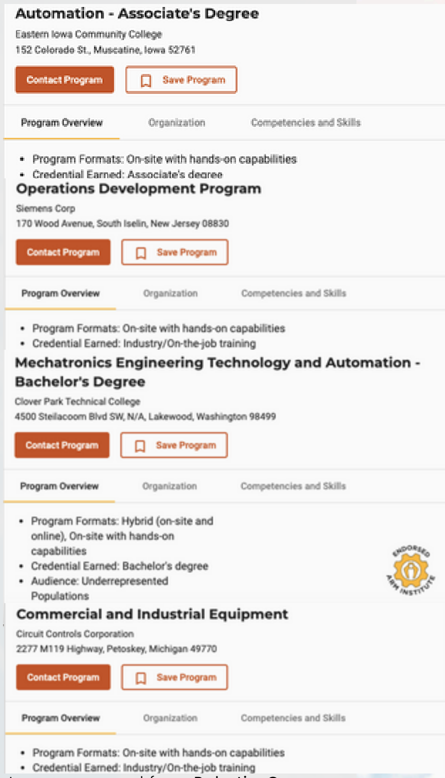
Online courses provide introductory knowledge for the employees to learn surface-leveled skills.

| Online Courses | |
|---|---|
| Course 1 | ETHx: Autonomous Mobile Robots |
| Outcome | Be able to apply basic concepts of basic concepts and algorithms required for mobile robot locomotion for the design and implementation of autonomous mobile robots acting in complex environment |
| Duration | 60 hours in total, 7.5 hours per week |
| Course 2 | Selenium WebDriver with Python Crash Course |
| Outcome | Learn how to write Selenium WebDriver scripts using Python scripting language |
| Duration | 2 hours in total |
| Course 3 | Automatic Control System |
| Outcome | Understand function for each components of Automatic Control Automatic Control System (ACS) & Programmable Logic Controller (PLC) |
| Duration | 6 hours in total |

## b. External Programs

- Community College
  - all employees will be able to attend
  - accessible and scalable upskilling and foundational education
  - E.g.: Automation - Associate's Degree
- Advanced Manufacturing Certification Program
  - employees will attend different programs depending on their roles
  - validate critical technical skills for advanced technologies
  - E.g.: Operations Development Program
- Technical Colleges
  - specialized education and training to prepare students for careers in specific technical fields
  - training existing employees to adapt to new automated manufacturing systems
  - E.g.: Mechatronics Engineering Technology and Automation - Bachelor's Degree
- Apprenticeship Program
  - few employees who demonstrate strong learning abilities will attend
  - long-term workforce development
  - E.g.: Commercial and Industrial Equipment

To maintain the continuous operation of the company, employees are separated into rotational groups for the external training programs to ensure a sufficient amount of workers remain in the company.



Images sourced from RoboticsCareer.org

## c. On the Job Training

- Shadowing and Mentorship
  - Learning directly from experienced professionals in automation or electronics manufacturing.
- Vendor-Specific Training
  - Training done by specific companies due to their needs
  - E.g.: SITRAIN from Siemens is an industrial training program specifically designed for employees in Siemens to operate their machineries, some examples of their course offerings are: Industrial Automation SIMATIC, Operator control and monitoring systems

# IV. Measurable Outcomes

To evaluate the effectiveness of the training programs, a set of objectives has been established.

- Each program has a completion rate of at least **80%** and a proficiency rate of at least **70%** after the training program, measured by ongoing assessments .
- Monetary efficiency should increase by at least **15%** within six months after the initiation of the training program.
- Total Recordable Incident Rate (TRIR) should decrease by at least **0.2 points** within three months after the program ends
- Failure rate and defect rate should both decrease by at least **0.05%** within three months after the programs ends.
- Machine downtime should be reduced by at least **15%** within three months after the program ends.
- The Employee Satisfaction Index should grow by **10%** within one month after the program ends.
- The time required for quality control processes should decrease by **10%** within three months of completing the training program.
- The scrap rate should be reduced to **2%** within two months after the program ends.
- $CO_2$ emissions should reduce by **10%** due to automation and improved efficiency within 6 months after the training program.

# V. Timeline

### Month 1-2

#### Online courses

- Employees complete foundational online courses while continuing their regular work.

### Month 3-47

#### External Training Programs

- Employees to go training programs organized by other institutions rotationally
- Depending on their performance, they may choose to continue going into other institutions or go back to work.

### Month 48-50

#### On-the-Job Training

- Employees apply the skills they attained onto actual workplace through shadowing and mentorship.

# Recruitment Strategy

## Recruitment Funnel

Aside from training the existing employees, recruitment of new talent is also crucial. The recruitment funnel method is a series of steps that strategically outlines the entire hiring process, from sourcing candidates to selecting the right talent, ensuring a steady pipeline of qualified individuals.

| | |
|---|---|
| 1. Awareness | Establish the industry recognition so that it is seen by potential candidates. |
| 2. Attraction | Advertise to the audience who have known but not yet applied to the position. |
| 3. Interest | Provide detailed digital resources for them to understand what is offered. |
| 4. Applying | Encourage and facilitate the application process for the positions. |
| 5. Evaluating | Evaluate the candidates' skills, experience, and knowledge in depth. |
| 6. Interviewing | Conduct interviews to examine candidates' personalities and soft skills. |
| 7. Hiring | Offer compelling reasons for candidates to pursue the electronics quality control field. |

Employers' needs are not for temporary positions, but for employees who can hold consistent, long-term occupations. Companies must recognize this in order to recruit individuals with the skills to operate automated machinery as technology advances.

# Partnering with Schools

When recruiting, it is important to establish reliable partnerships with institutions that consistently provide a pipeline of skilled talent. By building strong relationships with selected schools, the company can ensure a steady inflow of well-trained candidates each year.

By viewing and selecting schools from RoboticsCareer.org, companies can be confident that they are choosing reliable institutions that specialize in developing the necessary skills for automation, robotics, and advanced manufacturing. These partnerships ensure a consistent flow of trained candidates who are prepared for the evolving demands of the industry.

To choose the most suitable schools, some important factors to consider are:

- Geographical Proximity
- Credentials/Certifications
- Length of the Program

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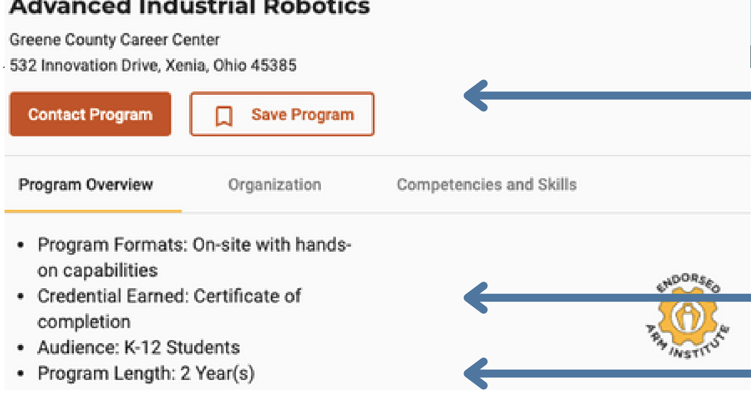
All of the above information is clearly and concisely presented in the program overview section on RoboticsCareer.org, which acts as a reliable platform for identifying schools and training programs that align with the company's recruitment needs.

Example Page on RoboticsCareer.org:




Location

Credential

Program Length

# Financial Outlook

To quantitatively demonstrate the positive impact on automation in electronics manufacturing quality control, if the company currently makes an annual revenue of $10,000,000, and spends $2,000,000 as labor cost, $300,000 as maintenance cost, and $500,000 as cost of quality, by automation, they can achieve an estimated saving of $360,000. This is also detailed by the financial graphs below:


| | Cost Before Automation($) | Cost After Automation($) | Savings($) |
|---|---|---|---|
| Labor Cost | 2,000,000 | 1,700,000 | 300,000 |
| Maintenance Cost | 300,000 | 255,000 | 45,000 |
| Cost of Quality | 500,000 | 485,000 | 15,000 |
| Total | 2,800,000 | 2,440,000 | 360,000 |

# Environmental Outlook

Automation also leads to reduced waste production and increased energy efficiency. By optimizing processes and reducing human error, automated systems can improve accuracy and decrease material waste. With the assumption that the company produces 50 million electronics annually and the outcome objectives being successfully fulfilled, the following calculations can be made to determine automation's effect on energy efficiency and waste production by electronics manufacturing industry:

### Energy Efficiency

## 210 tons of CO2 Reduced

50 millions*95.1kWh/unit=4.755billion kWh
4.755 billion kWh*0.45kg = 2,100 tons of $CO_2$ annually
2100*10% = 210 tons of CO2 reduced

### Waste Production

## 1 million electronics saved

50million unit*(5%-3%)=1 million units

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