Amp It Up! Engineering/Technology and Industry Lesson Extension

Teacher Name(s), School and District: Donna M. Costa, Peabody Veterans Memorial High School, Medtronic, Inc.

Course Name: Electronics

Lesson/Unit Name: Programming a Robotic Arm to Run a Manufacturing Job.

Science or Education Topic(s): Programming, Robotics, Automation, Manufacturing, Career and College Exploration

Engineering Technology Industry Related Field/Activity: Program a Robotic Arm, Activate a Sequence on a Manufacturing Line using Programmable Logic Controllers (PLC's), Research Postsecondary Education Needed for Specific Careers in the Medical Field, and Research Career Opportunities at Medtronic, Inc. in Danvers.

When Taught: March in Electronics 4 Classes.(lesson developed April 2016)

Abstract: The series of lessons is based on automated manufacturing processes that could be utilized at Medtronic for faster and more accurate production of parts utilized in medical equipment. Medtronic is a medical company that strives to manufacture effective medical "instruments or appliances that alleviate pain, restore health, and extend life." Medtronic has been working hard to rearrange their employees' responsibilities to produce more medical products in a shorter amount of time with fewer mistakes. Robotic automation could assist in producing medical parts in a faster and more accurate process. Additionally, over time, the parts would be cheaper to produce once the programming and the initial adjustment to automation is complete. Although some repetitive jobs could be eliminated; the need for highly skilled technicians would increase with the use of Robotic Automation and Programmable Logic Controllers (PLC's). Overall, could Medtronic benefit from integrating robotic automation and programmable logic controllers to perform the work on their production lines?

Five lab activities relate to automated production for the medical industry (students work in two teams of eight): Record position points in a robot's memory (source: Amatrol Pegasus Robotic Arm); Use a teach pendant to set position points (source: Amatrol Pegasus Robotic Arm); Use a computer program to set position points (source: Amatrol Pegasus Robotic Arm software); Use Programmable Logic Controllers (PLC's) to simulate a production line (source: Amatrol Multimedia software, and Amatrol Inventory, Gauging, and Distribution stations with software); and Demonstrate safety procedures in the lab environment at all times.

The last activity involves students working in pairs to research careers and education required to be productively employed in the electronics manufacturing area in the medical field.

Objectives and assessment: Using the table below, identify at least 3-5 learning objectives (content and/or pedagogical) and describe how each will be assessed.

Objectives *By the end of this lesson/unit, the students will be able to:*	**Assessment** *How was the objective assessed? List the example of formative or summative assessment.*
Describe the function and operation of the Amatrol Pegasus robotic arm.	Write a two-page document reflecting on the function and operation of the Amatrol Pegasus robotic arm.
Describe how position points are recorded in a robot's memory.	Demonstrate how position points are recorded in a robot's memory.
Use a teach pendant to set position points.	Demonstrate how to use a teach pendant to set position points.
Use a computer program to set position points.	Demonstrate how to use a computer program to set position points.
Describe how to stop a robotic arm in case of an emergency.	Demonstrate how to stop a robotic arm in case of an emergency.
Describe how to send a robotic arm back to home place.	Demonstrate how to send a robotic arm back to home place.
Design a robot program to perform a basic material handling task to work in a manufacturing line using Amatrol PLC's.	Demonstrate how to drop three pucks into a cylinder to start a process on a manufacturing line for picking and placing materials in a specific bin, separating good parts from bad parts, and sorting parts.

Engineering/Technology Link: Please check the appropriate box(es) in question 1. And provide a brief answer to question 2.:

1. How did you *introduce* engineering/ technology concepts or the company/industry focus in your course? Check the appropriate box(es) or choose Other.

   - [X] Defined terms (science, engineering, technology)
   - [X] Described the engineering design process
   - [X] Engineering design challenge related to industry
   - [X] Overview of the company
   - [X] Challenge based on 'industry specific' area of focus (manufacturing process, quality control, development, teamwork, etc.)

[X] Other: Technical Writing

2. After introducing the concepts, what did/will the students do to explore and apply the engineering/technology and industry specific concepts? (include information about the actual activity students did, discussions they had, or instructional strategies you used).

Students will program the robot to drop three different types of pucks in a cylinder to start a production line of inventory, gauging, and distribution. The puck must drop just right in the cylinder; otherwise, it gets stuck. Different pucks require different points. Trial and error is constant with this process. Students must continue to set points until the pucks drop consistently in the cylinder in the correct manner. Students had a difficult time understanding that the pucks had to be placed in the exact spot when starting the production line. Students also realized that the points must be extremely accurate; otherwise the production line stops. Students engaged in the eight step engineering process when setting up different points for different parts with a focus on testing and evaluating the position points and continuously improving the design until the production line continuously worked effectively.

Level of Inquiry: Which of the following best describes the level of inquiry (adapted from Bell 2005) you used for this lesson/unit? Check the appropriate level.

[X] *Guided inquiry*: Instructor provides question. Students design procedure and determine the results.

Lesson Extension Plan:

Title/Topic: Robotics, Automation, and Manufacturing in the Medical Industry.
Time (minutes): Multiple Classes: Technical Writing, Educational and Career Research, Robotics, Automation, and Programmable Logic Controllers (PLC's).
Company Name and brief Description: Medtronic, Inc. is a biomedical engineering company that researches, designs, manufactures, and sells "instruments or appliances that alleviate pain, restore health, and extend life." Medtronic employs 85,000+ employees, has 53,000+ patents, is located in 460+ locations around the world, serves patients in 155+ countries, and in 2015 donated 97.8 million dollars to charitable contributions. Medtronic has groups of employees that focus on cardiac vascular (46%), restorative therapies (33%), minimally invasive therapies (12%), and diabetes (9%). Medtronic is the leading medical company in the world for sales of catheters utilized in cardiac care.
Overview of the Lesson: The lesson involves introducing students to automation techniques in manufacturing processes, programming a robotic arm and

programmable logic controllers (e.g., inventory, gauging, and distribution). There are five lab activities and one writing activity, as well as a career research activity.

Standard(s)/Unit Goal(s) to be addressed in this lesson: (from the Vocational Technical Education Framework: Manufacturing, Engineering, & Technology Occupational Cluster/Electronics, CIP Code 150303, June 2014)

Strand 2: Technical Knowledge and Skills

2.A Safety in the Electronics Laboratory

2.A.01 Demonstrate safe practices within the electronics laboratory following OSHA regulations, industry standards and established shop safety procedures.

- 2.A.01.03 Practice work habits that provide personal safety, safety for others, and protect the safety and security of the external environment.
- 2.A.01.04 Select and use appropriate personal protective equipment at all times.
- 2.A.01.05 Maintain a sanitary and clutter-free work environment.

2.G Applied Engineering

2.G.01 Utilize engineering concepts.

- 2.G.01.01 List and apply the steps of the design process to designated electronics projects.
- 2.G.01.02 Utilize the steps of the design process to solve given problems.
- 2.G.01.03 Work in teams using brainstorming techniques to create new designs.
- 2.G.01.05 Describe and use the steps for troubleshooting a given problem.

2.G.04 Design an autonomous robotics system.

- 2.G.04.01 Utilize sensors to interface in a robotic control system.
- 2.G.04.02 Design, build, and operate an autonomous robot.

2.H Software Applications

2.H.01 Utilize programming.

- 2.H.01.01 Write a simple control program using a programming language.
- 2.H.01.02 Simulate a circuit using a software simulation program.

Strand 3: Embedded Academic Crosswalks

3.B. English Language Arts and Literacy

3.B.03.01 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

<u>Strand 4: Employability and Career Readiness</u>

4.A Career Exploration and Navigation

4.A.01.02 Assess personal strengths and interest areas to determine potential careers, career pathways and career ladders.

4.A.01.04 Research and evaluate a variety of careers utilizing multiple sources of information and resources to determine potential career(s) and alternatives.

4.A.01.05 Identify training and education requirements that lead to employment in chosen field(s) and demonstrate skills related to evaluating employment opportunities.

4.A.01.06 Explore and evaluate postsecondary educational opportunities including degrees and certifications available, traditional and nontraditional postsecondary pathways, technical school and apprenticeships, cost of education, financing methods including scholarships and loans and the cost of loan repayment.

4.A.02 Demonstrate job search skills.

4.A.02.02 Explore and evaluate postsecondary job opportunities and career pathways specific to career technical areas.

4.B Communication in the Workplace

4.B.01 Demonstrate appropriate oral and written communication skills for the workplace.

4.B.01.01 Communicate effectively using the language and vocabulary appropriate to a variety of audiences within the workplace including coworkers, supervisors and customers.

4.B.02 Demonstrate active listening skills.

4.B.02.01 Listen attentively and respectfully to others.
4.B.02.02 Focus attentively, make eye contact or other affirming gestures, confirm understanding and follow directions.
4.B.02.03 Show initiative in improving communication skills by asking follow-up questions of speaker in order to confirm understanding.

4.C Work Ethic and Professionalism

4.C.06 Interact appropriately with coworkers.
4.C.06.01 Work productively with individuals and teams.
4.C.06.03 Show respect and collegiality, both formally and informally.
4.C.06.06 Negotiate solutions to interpersonal and workplace conflicts.

Strand 6: Technology Literacy Knowledge and Skills

6.A Technology Literacy Knowledge and Skills (Grades 9 through 12)

6.A.01 Demonstrate proficiency in the use of computers and applications, as well as an understanding of the concepts underlying hardware, software, and connectivity.

Essential Question(s) addressed in this lesson: How do you program the robotic arm so that three different size and shape pucks will be picked up in sequence (repetitive movements for different pucks)? What happens to the puck once it is successfully dropped into the cylinder at the inventory station? What happens to the puck after it goes into the indexing and gauging station? What happens to the puck once it goes into the distribution station? How could robotic automation be utilized in the medical manufacturing industry?

Objectives: To program a robotic arm so that a production line will perform repetitive tasks. The robotic arm must pick up three pucks of different weights and drop them in a cylinder so that each puck successfully moves through three stages of a production line: inventory, gauging, and distribution.

Link to Industry: Medtronic is continuously trying to increase production of medical parts and supplies at a lower cost. Therefore, cost savings moving onto the consumer of medical supplies. One example is that Medtronic is currently trying to make more catheters per day by moving fewer employees to work on a specific production line. Overtime, implementation of robotic automation could improve production, reduce mistakes, and save money.

What students should know and be able to do before starting this lesson: Students should understand the importance of automation in manufacturing processes.

Instructional Materials/Resources/Tools:

Equipment:
Amatrol Pegasus Robotic Arm #880-RA1-1-B Robotics 1 Learning System
#880-RA2-1-B Robotics 1 Learning System
Amatrol Programmable Logic Controllers (PLC's)
Amatrol Tabletop Mechatronics:
Processing Stations: Inventory (pick and place parts)
Indexing and Gauging (processing of good & bad parts)
Distribution (separates parts into different areas)

Compressed Air Supply
Computer with Windows 7
Printer

Supplies: Three different size pucks.

Black Puck	Pad of Paper
Silver Puck	Masking Tape
White Puck	Pencil

Software:
Pegasus Control Software
Tabletop Mechatronics Software
RS Logic 500 Software (Inventory, Gauging, & Distribution Stations)
Amatrol Interactive Multimedia Curriculum Software

Text and Lab Manuals:
Amatrol Robotics 1/LAP 1 – Basic Robot Operation: Power Up and Shutdown, Manual Operation, Homing, and End Effector Operation.

Amatrol Robotics 1/LAP 2 – Basic Robot Programming: Teaching Points, Basic Programming, and Movement and Effector Commands.

Amatrol Robotics 1 Student Reference: Basic Robot Operation, Teach Pendant Operation, Basic Robot Programming, and End Effector Operation.

Amatrol Tabletop Mechatronics Servo Robot Student Reference: Programming a Servo Robot, Programming a Servo Conveyor, Interfacing a Robot to A PLC, Function of a Robot-Based Inventory System, Robot-Based Inventory System Operation, Function of a Robot Work Envelope, and Programming Conditional Commands.

Amatrol Tabletop Mechatronics Student Reference: Introduction to Mechatronics, PLC Programming, Sensor Adjustments, Pick and Place Feeding, Gauging Operations, Indexing and Sequencing, Parts Sorting and Distribution, Multiple Station Control, and Mechatronics safety.

Lesson Delivery
Lesson Opening: Introduction to Medtronic and the medical manufacturing industry. Discourse focused on automated manufacturing processes utilized in the medical field. Students became familiar with the different types of software used for the Amatrol robotic arm and programmable logic controllers (PLC's). Students studied the function and operation of the Amatrol Tabletop Mechatronics Learning System, including the Pegasus Robotic Arm and the Amatrol PLC's with three stations: Inventory, Gauging, and Distribution. Students worked in teams and were required to relate the steps utilized in the Engineering Design Process to manufacturing processes, including identifying the need and constraints, researching the problem, developing possible solutions, selecting a promising solution, designing a prototype, testing and evaluating the prototype, and redesigning and evaluating as necessary.
During the Lesson (activities/labs/challenges): Students performed the following labs: <u>Robotic Arm:</u> Students started out identifying the different components of the robotic arm. Robot safety was an integral part of every lesson. Students demonstrated how to power up and shut down the robot. They used the teach pendant to set points to pick up a puck and drop it into a cylinder. After demonstrating the points that were set using the teach pendant, students also demonstrated how to set points by using the robotic software. Speed settings were utilized when demonstrating how to pick up a puck. Finally, students demonstrated how to use robot commands to program the robot to show how the robot gripper is used for basic material handling tasks. In summary, students identified robot components, programed the robot using the teach pendant and the software, interfaced the robot with PLC's, and demonstrated how to use conditional commands for specific job requirements. Note that students implemented trial and error techniques to learn how to program the robotic arm to pick up each different puck just right to drop it into the cylinder. They learned that different sizes and weights needed different points to work effectively. Some other challenges that students struggled with were that the starting points had to be different for different puck placements, they had to put each puck in the same exact spot to be picked up properly, and utilizing more points caused the robotic arm to perform more effectively. <u>Programmable Logic Controllers)PLC's):</u> Again, students started the lab by identifying the three different stations (e.g., inventory, gauging, and distribution) and learned how each station worked, explaining the purpose and function of each station. Students then became familiar with the PLC software. Before using the PLC's, students learned about sensors and safety. They studied the purpose and function of each station and then demonstrated how each station worked separately. Students showed how the puck would be dropped into the cylinder of the inventory station. Students demonstrated how the gauging station separates the good versus the bad parts and how the distribution station sorts the parts. Finally, students hooked all of the three stations together and demonstrated the production line from start to finish.

This process involved programming the robotic arm to pick up three pucks and drop each one in the cylinder separately and then demonstrated how the pucks moved from the first station, inventory, to the last station, distribution. Hence, a manufacturing production line was simulated.
Lesson Closing: Finally, at the conclusion of the labs, students were individually required to write a two-page reflection paper on the process and outcome of their work, focusing on the challenges that surfaced while working collaboratively. Additionally, students worked in pairs to research careers and education required to be productively employed in the medical electronics manufacturing field. Class time was devoted to collaborative discussions of what students learned and the challenges they encountered.
Assessment
Student Assessment: Student assessments were based on a two-page written document regarding the operation of a robotic arm used in manufacturing processes. Another assessment involved the individual demonstrations by each team participant showing how to program position points on the robotic arm so that the production line (PLC's) separates three different size and shape pucks.
Delivery Assessment: Students gave daily feedback regarding concerns about software, the performance of the robotic arm movements, and the functions of the programmable logic controllers (PLC's). They performed daily research and made suggestions about improving the lab activities.

Additional resources and assessments: List the attachments here.
Attachments should include handouts, readings (with references), lab write-ups, rubrics, exams/quizzes, and/or other similar materials.

Automated Manufacturing Lab: Donna M. Costa, Peabody High School 2016

Attachment 1: Amatrol Tabletop Mechatronics: Pegasus Robotic Arm with Three-Station Programmable Logic Controllers (PLC's).

Purpose: Program the robotic arm to start a production line on PLC's.

Prior Knowledge: Understand the importance of automation in manufacturing processes.

The work being done at Medtronic involves creating strategies that are cost effective and produce more medical parts in a shorter length of time with fewer mistakes.

Tabletop Mechatronics is a field of study focusing on the integration of mechanical, electrical, fluid, and computer technologies to control machine movements.

Attachment 2: Pegasus Robotic Arm and Three Station Programmable Logic Controllers (PLC's).

Purpose: Automated production line utilizing one robotic arm and three manufacturing stations:

1. Inventory Station – Pick and Place parts (robot arm picks up the part and places it into the cylinder).
2. Indexing and Gauging Station – Separates Good Vs Bad parts.
3. Distribution Station – Sorts parts (white, silver, and black pucks are separated by a sensor that uses weight to sort)

Prior Knowledge: Understand the relevance of Robotics and Programmable Logic Controllers in manufacturing processes.