TATA CONSULTANCY SERVICES | Discovery EDUCATION

IGNITE MY FUTURE

THINK | SOLVE | CREATE | CONNECT

LESSON TITLE

Capable Cobot

Guiding Question: What will our future look like?

SUBJECTS

Science
Math

COMPUTATIONAL THINKING PRACTICE

Creating Computational Artifacts

COMPUTATIONAL THINKING STRATEGY

Develop Algorithms

MATERIALS

Cobots and Algorithms student handout

Wired Help capture sheet

Flip chart
(index cards or post-it notes can also be used)

Whiteboard or chalkboard

Computers with internet access

Graph paper

Writing utensils

Ignite Curiosity

- Is it possible to teach a robot to do chores that we don't like to do, such as taking out the garbage and washing dishes?
- Can robots learn and make decision like humans?
- How can we take care of our friends and family members as they age?

In this lesson, students will utilize the computational thinking strategy of developing algorithms to solve a real-world STEM problem: charting the course for a cobot (a robot designed to assist a person) that completes chores for the elderly. In **THINK**, students will act as computer scientists tasked with developing a cobot that can help elderly people and people with physical limitations complete routine household tasks. They will analyze information about current robotics technologies in medical and personal assistance fields to learn what tasks cobots can achieve. After reviewing this information, students will form teams and review three tasks that they will program a cobot to complete. In **SOLVE**, students will work in teams to design an algorithm that directs a cobot around a two-story house to accomplish the three tasks. In **CREATE**, students will create a visual map of their algorithm by designing a floor plan of a home and drawing their algorithm on the floor plan. In **CONNECT**, students will seek to answer the following critical question: Can technology enable seniors and disabled individuals to live more independently by performing everyday tasks for them? Students will also investigate careers in robotics and medicine that rely on algorithms.

Students will be able to:

- **Understand** how robotic technology is used in medical and personal assistance fields,
- **Create** an algorithm in two formats, a flowchart and a map, to simulate the path of a personal assistance cobot, and
- **Evaluate** their artifacts by editing and fixing errors.

Students act as computer scientists tasked with developing a cobot that can help elderly and disabled people by completing routine household tasks.

1 **Read** the following scenario to students:
Imagine you are a computer scientist specializing in robotics. Your focus is to design a cobot that helps elderly people and those with physical limitations live more independent lives. Your current work is inspired by an elderly family member who lives alone and is finding it increasingly difficult to keep up with his household chores, such as vacuuming, dishwashing, keeping things tidy, and taking out the garbage. He also seems lonely and really enjoys when you visit. He is a good candidate for moving to an assisted-living facility, but he enjoys his independence and wants to stay in the familiar surroundings of the home he has owned for many years.

2 **Ask** students if they can relate to what it would be like to grow old and to start losing the ability to care for yourself or have physical limitations and wish to live as independently as possible.

3 **Discuss** the distinctions between robotics, such as "smart homes" that have been wired to monitor the movements of their occupants, and cobots, which can provide a wide range of services with or without other robotic assistance.

4 **Distribute** articles related to projects that have attempted to use cobots and/or robotics to assist the elderly. Ask the students to read the articles and be prepared to discuss the outcomes during the next class period. Here is a list of potential articles to consider:

- Affective Robot for Elderly Assistance (National Institutes of Health)
- Robotic Surgery (The Mayo Clinic)
- A Robot Is My Friend: Can Machines Care for the Elderly? (BBC)

5 **Guide** students in a discussion about how robotics can be used in healthcare facilities. Invite students to suggest current and potential uses and collect their thoughts on a whiteboard or in another central location. Continue the discussion with students by exploring robotic assistance during surgeries. There are several types of surgery in which robotic assistance can be very useful. For example, in open-heart surgery the rib cage must be spread to access the heart. Robotic arms are now being used to assist in this process and to act as an extension of the surgeon's hands in performing these operations. Robotic assistance is also used in more common healthcare applications, such as lifting patients onto stretchers to allow the changing of bed linens.

6 **Researchers** have identified a common problem in providing robotic assistance to the elderly: many people who could benefit from this assistance are unwilling to accept the help. Guide students in discussing this difficulty by asking the following guiding questions:

- Why might elderly people resist robotic assistance?
- Why might people with physical limitations resist robotic assistance?
- How could you, as a computer programmer, find out why people do not want robotic assistance?
- How could designers and computer programmers make cobots more accessible or desirable to people they could help?

7 **Ask** students to summarize the real-world problem they have been asked to solve (helping the elderly and disabled to complete household chores through robotic assistance).

Students will work in teams to design an algorithm that directs a cobot around a house to accomplish three tasks — vacuum the carpets on the first floor of the house, put away all the clothes on the floor in the first-floor bedroom, and take out the garbage in the kitchen. Student groups will develop a floor plan of the home and must guide the cobot through the three tasks while paying attention to the constraints of the home (e.g., stairs, liquids).

1. **Introduce** students to algorithms by distributing the Cobots and Algorithms student handout. Students should answer the questions individually, then discuss their answers with a partner. After students have had a few minutes to discuss the questions, reconvene the class and discuss students' answers.

2. **Define** algorithms to students:
   - Algorithms are a series of steps to be taken to accomplish a task. The steps can be written in any language, including simple English. (The difference between algorithms and computer code is that the steps in an algorithm are more general and do not usually worry about errors that can happen, while computer code needs to be written in a language that the computer can understand, and every possible error condition needs to be taken into account.)
   - Use the three tasks to be done as an example of an algorithm. In what order should they be performed? (One possible algorithm would be to first take out the garbage, then pick up all the clothes and put them away, and then vacuum the carpets. Note that vacuuming the carpets will be easier if that task is done last because the bedroom is on the first floor.)

3. **Instruct** students that they will be planning the course of a cobot that will accomplish the following three tasks:
   - Vacuum the first floor of a house
   - Put away all of the clothes on the floor of the bedroom
   - Take out the garbage in the kitchen

4. **Divide** students into teams. Have each team write down a list of requirements/constraints for the cobot based on the three tasks it has to accomplish. The list should include the following:
   - Cobot must be able to climb stairs (references made to first floor)
   - Cobot must be able to operate indoors and outdoors (take out garbage)
   - Cobot must be able to vacuum and pick up items

5. **Using** their list of constraints, guide students to write down step-by-step instructions for the cobot on how to complete the tasks.
   - Example: Go to a room that has a garbage can, collect the garbage into a container such as a large plastic bag, repeat until all rooms containing garbage have been visited, then take the large container to the garbage bin on the curb. Deposit the container into the garbage bin.

6. **Ask** students to review the document to see if there are any requirements that haven't been covered. Remember, a cobot is like any general-purpose computing device—it can only do what it has been told to do in very specific terms.

7. **Ask** students to identify how the list of tasks they created works as an algorithm. If they were to follow the instructions listed here, would they be able to accomplish all the tasks without errors? Why or why not? Explain to students that building a visual model, such as a map, helps us catch errors in algorithms.

Students will create a visual algorithm by drawing a map of their cobot's path on a floor plan.

1. **Distribute** the Wired Help capture sheet to students.

2. **Using** their written lists of requirements and instructions, have students complete the capture sheet in teams. As they complete the capture sheet, they will be instructed to draw a floor plan that demonstrates their cobot's path. Distribute graph paper and writing utensils for students to use when drawing their floor plans.

3. **Provide** students with 20 to 30 minutes to create their floor plans. As they go, encourage students to refine their step-by-step instructions.

4. **When** students have completed their floor plan of the cobot's path and edited their algorithms accordingly, ask teams to switch copies of step-by-step instructions. The teams will now attempt to follow the algorithm the other team created to complete the task and draw what they think the floor plan of the other team looks like. When they are finished, they will give the algorithm and new floor plan back to the original team. The original team will assess the strength of its algorithm by how accurately the other team completed its floor plan.

5. **When** team have switched back, engage the class with the following questions:
   - Was your algorithm thorough? Why or why not?
   - What aspects of directing the cobot did your team forget?
   - Were the algorithms of the different teams mostly similar or mostly different? Why do you think that is?
   - Why are accurate algorithms important?

Select one of the strategies listed below to help students answer these questions:

- **How do this problem and solution connect to me?**
- **How do this problem and solution connect to real-world careers?**
- **How do this problem and solution connect to our world?**

1. **Write** the three questions on PowerPoint or flip chart slides and invite students to share out responses.
2. **Display** pieces of chart paper around the room, each with one question written on it. Ask students to write down their ideas related to the questions on each sheet.
3. **Assign** one of the questions to three different student groups to brainstorm or research, and then share out responses.
4. **Invite** students to write down responses to each question on a sticky note, and collect them to create an affinity diagram of ideas.

How does this connect to students?

Many students have elderly relatives and friends with disabilities. Students often observe loved ones providing care for these individuals, a job that can often be taxing. Providing care that allows the elderly and disabled to live more independently directly affects the infirmed individuals and caretakers in a student's life.

Cobots can be used to assist in the care of patients in nursing homes or during surgery for those requiring it. Students may not realize it, but there is a high likelihood that they or a loved one has undergone a medical procedure that involved robots in some way.

How does this connect to careers?

Computer Scientists invent and design new approaches to computing technology and find innovative uses for existing technology. They study and solve complex problems, including by using algorithms.

Computer Programmers write and test computer code that allows computer applications, such as robotics technologies, to function properly.

Software Developers develop applications that enable a computer to perform tasks.

Surgical Technologists arrange equipment in operating rooms and help doctors during surgeries.

How does this connect to our world?

The desire to live independently is important to everyone. With robotic technology, scientists and engineers can provide assistance to the elderly and disabled, allowing them to remain in their homes longer and preserving their quality of life.

More people can enter the healthcare world as robots remove some of the physical requirements for tasks such as lifting patients. However, as advances in the field of artificial intelligence are applied to robotics, many jobs may disappear from the workforce.

It is important that students think about these ethical dilemmas today in order to prepare for the economic challenges of tomorrow.

National Standards

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence ▪ Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	**ETS1.B: Developing Possible Solutions** ▪ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)	**Influence of Science, Engineering, and Technology on Society and the Natural World** ▪ The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

COMMON CORE STATE STANDARDS CONNECTIONS

ELA/Literacy

- **SL.8.5** Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

Mathematics:

MP.2 Reason abstractly and quantitatively.

7.SP Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

K-12 COMPUTER SCIENCE FRAMEWORK

Practice 5. Creating Computational Artifacts

The process of developing computational artifacts embraces both creative expression and the exploration of ideas to create prototypes and solve computational problems. Students create artifacts that are personally relevant or beneficial to their community and beyond. Computational artifacts can be created by combining and modifying existing artifacts or by developing new artifacts. Examples of computational artifacts include programs, simulations, visualizations, digital animations, robotic systems, and apps.

Cobots and Algorithms

Do you agree or disagree with these statements? Mark the boxes with a check mark to show agreement or disagreement. Then, compare your answers with those of a fellow student.

Statement	Me	Fellow Student
Algorithms are not the same as code.		
Cobots do exactly what you want them to do.		
Code is written before algorithms are developed.		
All elderly people will accept help from cobots.		
Elderly people want help in doing only specific tasks.		
The best way to solve a problem is to begin coding.		
Cobots will become the main way to provide aid to the elderly.		
There are no disadvantages to using cobots to aid the elderly.		

Wired Help (with example)

1 What is the task to be performed?
Example:

- Vacuum the living room.

2 On a separate sheet of paper,
provide a sketch of the room to be vacuumed. Include dimensions and any furniture that must stay in place during vacuuming.

3 What are the detailed steps involved in the task?
Write the steps in the order they are to be performed.
Example:

- Remove vacuum from its storage place.
- Unwind the cord.
- Plug in the vacuum.
- Go to the southeast corner of the room.
- Turn on the vacuum.
- Push the vacuum forward 18 inches.
- …
- Turn off the vacuum.
- Unplug the vacuum.
- Wind up the cord.
- Put vacuum back in its storage place.

4 What type of exceptional conditions are expected in performing the task?
Example:

- Running into a wall
- Running into a piece of furniture

5 What are the corrective procedures to be used when encountering an exceptional condition?
Example:

- Back up
- Turn around
- Turn to the left and proceed

Wired Help (blank)

1 **What is the task to be performed?**

2 **On a separate sheet of paper...**

3 **What are the detailed steps involved in the task?**
Write the steps in the order they are to be performed.

4 **What type of exceptional conditions are expected in performing the task?**

5 **What are the corrective procedures to be used when encountering an exceptional condition?**