STEAMCITY CURRICULUM

BIO-INSPIRED LEARNING PROCESSES

thematic: artificial intelligence and new technologies

Introduction

Learning is one of the fundamental processes that both humans and machines share, although the mechanisms can be very different.

In this activity, students will embark on an exploratory journey to discover **how a machine learns** and compare it to their own learning processes.

By engaging in **hands-on exercises**, they will understand both the challenges and methods behind learning through **trial and error**, and observe how **feedback**—positive or negative—can drive improvement.

The objective of this activity is to provide students with an **intuitive understanding of bio-inspired learning models** and how machines, similar to living organisms, use **trial and error to adapt and find solutions**.

By drawing parallels between their own learning strategies and those of machines, students will gain insight into how **artificial intelligence attempts to mimic natural learning processes**.

The activity is broken down into **three distinct stages**, each of which offers an immersive and practical experience of learning through experimentation. These stages will demonstrate the **iterative nature of learning** and emphasize the value of **adaptability**, a key feature needed to become a real **autonomous agent** in the city.

At the end of the activity, students should have a better grasp of **reinforcement learning principles**, **trial-and-error problem-solving**, and the **differences in adaptability between humans and machines**.

Interdisciplinarity

biology

technology, engineering

Sustainable Development Goals

4 QUALITY EDUCATION

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

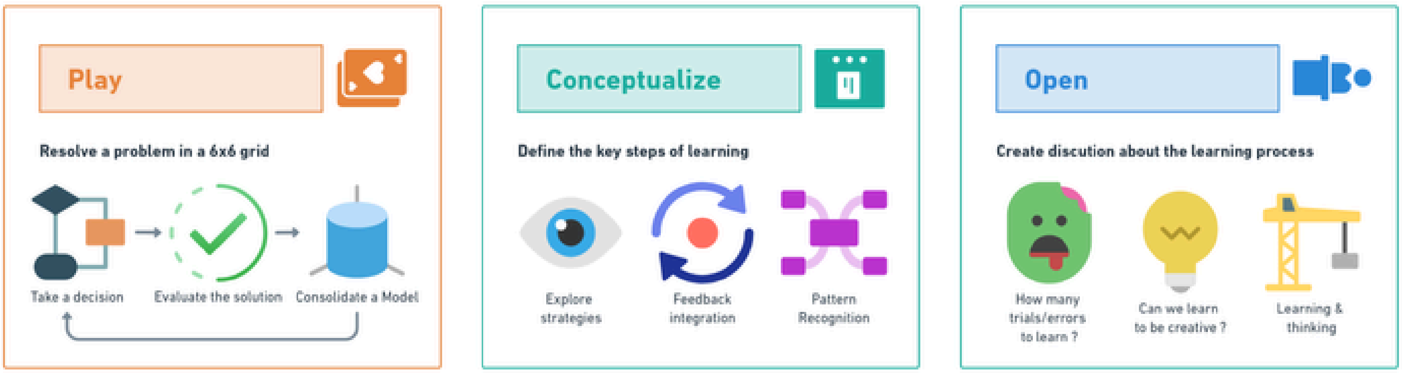
11 SUSTAINABLE CITIES AND COMMUNITIES

Overview

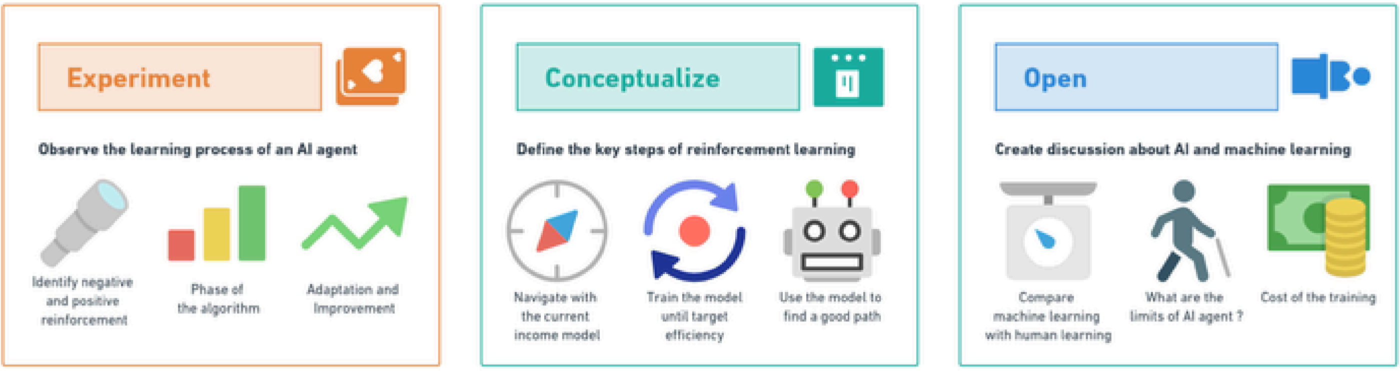
Protocol Structure

The activity will take place in **three main stages**, each designed to progressively introduce students to the concept of bio-inspired learning. Below is an overview of how the experiment is structured:

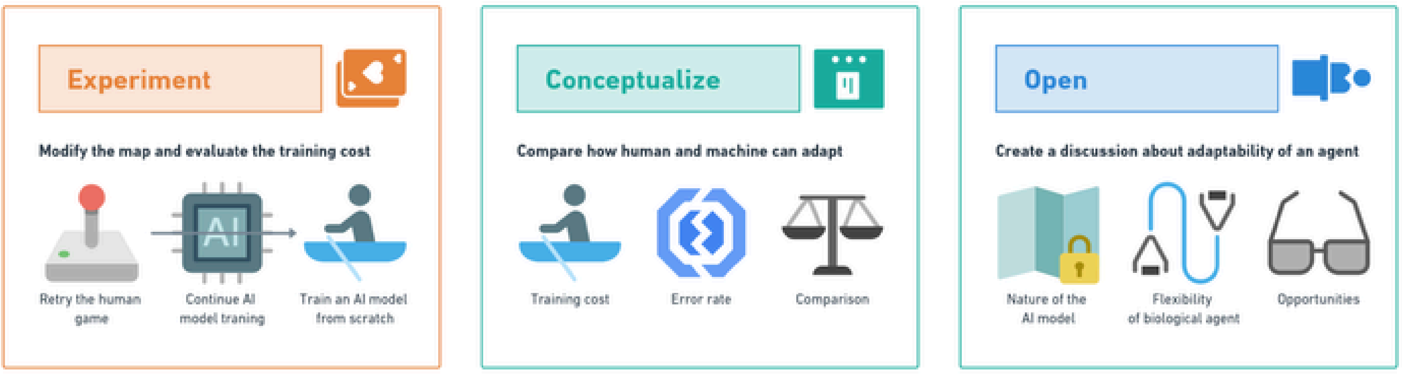
Step 1 - How do we learn?



Step 2 - How do machines learn?



Step 3 - Who is learning better?



Protocol Steps

Discover human learning through an unplugged game. Students will participate in a game using a 6x6 grid and a point that must be moved around. They can move the point in one of four directions (up, down, left, right), and each move results in either winning, losing, or continuing based on the teacher's feedback. The objective, which is not initially revealed, is for students to find the winning point. They will discover this through repeated trial and error and then attempt to find the shortest route.

Discover how machine learn. Students will use an online tool called **BioLearningGame** to observe how an AI attempts to solve the same problem. Like the students, the computer has no prior knowledge of the goal, and it must use trial and error to discover the correct path. This stage introduces students to the concept of machine learning models, reinforcement learning, and positive and negative feedback.

Adaptability of humans vs. machines. In this stage, students will compare their adaptability to that of the AI. They will split into two groups—one group modifies the city map, and the other group must navigate through the changes without seeing the map. Meanwhile, the computer model will attempt to learn the modified environment. The goal is to compare how quickly and effectively humans versus machines adapt to the new environment.

Getting started

Duration: The activity will be conducted over three sessions, each lasting approximately 45 minutes.

Level of difficulty: *Moderate.* ★★★☆☆

Material needed: 6x6 grid, marker, a computer or tablet for accessing the online tool, whiteboards for discussions.

Glossary

Keywords & Concepts	Definitions
Adaptability	The ability to adjust to new conditions. In this activity, it refers to how humans and AI modify behavior to achieve goals when circumstances change.
AI (Artificial Intelligence)	The capability of machines to imitate intelligent human behavior, including learning from experience and performing tasks autonomously.
Bio-Inspired Learning	Learning models based on natural biological processes, involving adaptation through trial and error similar to animal and human learning.
Feedback	Information about performance used for improvement. Positive feedback encourages behavior repetition, while negative feedback discourages undesirable actions.
Learning Model	A system for learning from data or experiences. In AI, it's the method by which machines update knowledge to improve actions.
Negative Reinforcement	Learning through negative consequences for incorrect actions, reducing likelihood of those actions being repeated.
Positive Reinforcement	Learning through rewards for correct actions, increasing likelihood of those actions being repeated.
Q-Learning	A reinforcement learning algorithm enabling AI to navigate environments by balancing exploration and exploitation of current knowledge.
Reinforcement Learning	Machine learning where agents learn decision-making by performing actions and receiving rewards or penalties.
Trial and Error	Learning method where different actions are attempted until successful outcome.
Iteration	Repeating a process to achieve a desired goal. In machine learning, it means repeating training cycles to improve performance.

Protocol

Step 1 - Discover Human Learning Through an Unplugged Game

Background and description of the problem to be solved in this step: In this first step, students will engage in a formal game designed to help them understand the concept of learning by trial and error without prior knowledge of the goal. The game uses a 6x6 grid where students need to move a marker point in one of four directions. Each movement will result in feedback—win, lose, or continue. This process helps students understand the dynamics of learning when the goal is not explicitly known.

Learning Objectives: **Core Competencies**: Understand learning by trial and error, develop problem-solving skills, and improve adaptability to achieve a hidden objective. **Auxiliary Competencies**: Develop spatial awareness, collaborative learning through group discussions, and basic strategy optimization to find the shortest path.

Conceptualisation

During this step, students will play an **unplugged game** to discover and explore the concept of **learning by trial** through a **ludified approach**. In order to launch the game, here is the typical course of a sequence. Students are given a **6x6 grid** (either drawn on the classroom board or printed to be used in smaller groups or individually - ***an example is given in annex***) and a **point marker**. They must move the marker in one of **four possible directions** (up, down, left, or right) and create a route to find their **final point goal**, i.e., a specific location on the grid. The teacher will act as the **"environment,"** giving feedback after each movement:

- **"Continue"**: The students can continue moving in an attempt to find the goal.
- **"Lose"**: The students have hit an obstacle or taken an incorrect path, and must start over from the beginning.
- **"Win"**: The students have reached the goal, and the game ends.

The key challenge is that students **do not know what the goal is or where it is located**. Through **repeated attempts and accumulating experience**, they will form **strategies**, **learn from previous mistakes**, and ultimately **identify the target point**. Once they discover the target, they will then work on finding the shortest path to reach it effectively.

Advice for Teachers: To ensure effective engagement during this session, consider different approaches based on the classroom setting and available time:

- **Whole-Class Demonstration**: You can use the game as a group task, by drawing a large 6x6 grid on the board and have one student come up to move the point based on the instructions given by their peers. This makes the activity interactive and promotes collaboration.
- **Individual Exercise**: Provide each student with their own grid and marker to attempt the activity independently. This can be used if there is enough time and you wish to see how each student approaches problem-solving without group influence.
- **Small Group Activity**: Divide students into groups of 4 to 6 and provide each group with their own 6x6 printed grid and a point marker. Each group can work together to determine the moves, fostering small-scale collaboration.

Adapt the method depending on classroom size, time constraints, and the level of student engagement. Using a mix of approaches can help maintain interest and provide different perspectives on the problem-solving process.

Students Investigation

Once the game context, rules and material (depending on the setting you chose) has been unveiled to the students, you can start **playing until students can find the correct route to reach the winning point location**.

When the game is finished, the teacher will initiate a discussion on how students approached the problem:

- **What strategies did they use to explore the grid?**
- **How did they deal with "losing" situations, and what adaptations did they make?**
- **How did they identify the goal and find the shortest route?**

Students will be encouraged to reflect on the importance of **trial and error** and **iterative learning**. They will understand that each failure provides valuable information that helps refine their future attempts. The teacher should also prompt students to think about **when** they began to understand the objective:

- **At what point did they start to recognize patterns in the feedback provided?**
- **When did they feel they were getting closer to identifying the target?**
- **How did their understanding evolve from initial random moves to more purposeful decisions?**

The goal is to demonstrate how learning is an **iterative process** where **mistakes are an essential part of gaining knowledge**. By discussing these aspects, students will gain insights into how their strategies changed over time, what specific moments helped them understand the objective, and how they could optimize their approach once the goal was identified.

Conclusion & Further Reflexion

In this step, students participated in a game that required them to learn through trial and error without prior knowledge of the goal. The aim was to illustrate how learning can be achieved incrementally by using feedback to adapt and improve. The teacher can use the **BioLearning site** to show a solution to students with the grid not revealed.

- **Knowledge Mobilized**: By the end of this step, students will have developed a concrete understanding of trial-and-error learning. They will learn how to adapt strategies in response to feedback and will realize that finding a solution often requires multiple attempts.
- **Classroom Implementation Reflection**: This game also fosters teamwork and communication. Students will likely collaborate, share their findings, and suggest strategies to one another. It is important to highlight that sharing knowledge can help speed up the learning process.
- **General Learning Outcomes**: Students will better appreciate the value of iterative learning and adaptability, crucial skills not only for human learning but also for understanding how machines, like AI models, learn through trial and error.

Unveilling the target

At the end of this step, reveal to the students that the grid represented a **city**, the point symbolized an **ambulance**, and the goal was to **reach the hospital**.

Explain that they received minimal information to **prevent them from using prior knowledge, thus simulating how a machine learns without pre-existing biases**.

Discuss how navigating the unseen grid allowed them to construct a "**mental model**" of the environment. Introduce the concept of **reinforcement learning** by explaining how successes positively reinforced their model—indicating the correct path—while failures negatively reinforced it by highlighting areas to avoid.

Emphasize that both **positive and negative feedback were crucial** for developing an effective strategy. This notion of a "**learned model**" will be essential in the next step, where students observe how a machine builds its own model to solve the same problem.

Opening discussions for Concluding on Step 1

To conclude this step, students will engage in a discussion centered on open-ended questions. These questions are designed to encourage deeper reflection on the exercise and its broader implications. Here are ten examples of questions that could be discussed:

1. How did your approach to finding the goal evolve as you received more feedback, and what pivotal moments made you realize you were getting closer to the goal?
2. What emotions did you experience when you had to start over after losing, and how did these feelings influence your strategy, along with the cruciality of remembering your previous moves?
3. In what ways did collaborating with classmates enhance your understanding of the objective, and how do you think the concept of building a 'mental model' applies to other subjects or tasks you learn?
4. How did navigating without knowing the goal compare to your experience after learning the hospital's location, and what similarities do you think exist between the challenges you faced and those encountered by machines during this type of learning?
5. How do you believe the trial-and-error process improves your ability to solve new problems in real life, and in what ways might this experiment help you understand the limitations of both human and machine learning?

Step 2 - Discover How Machines Learn

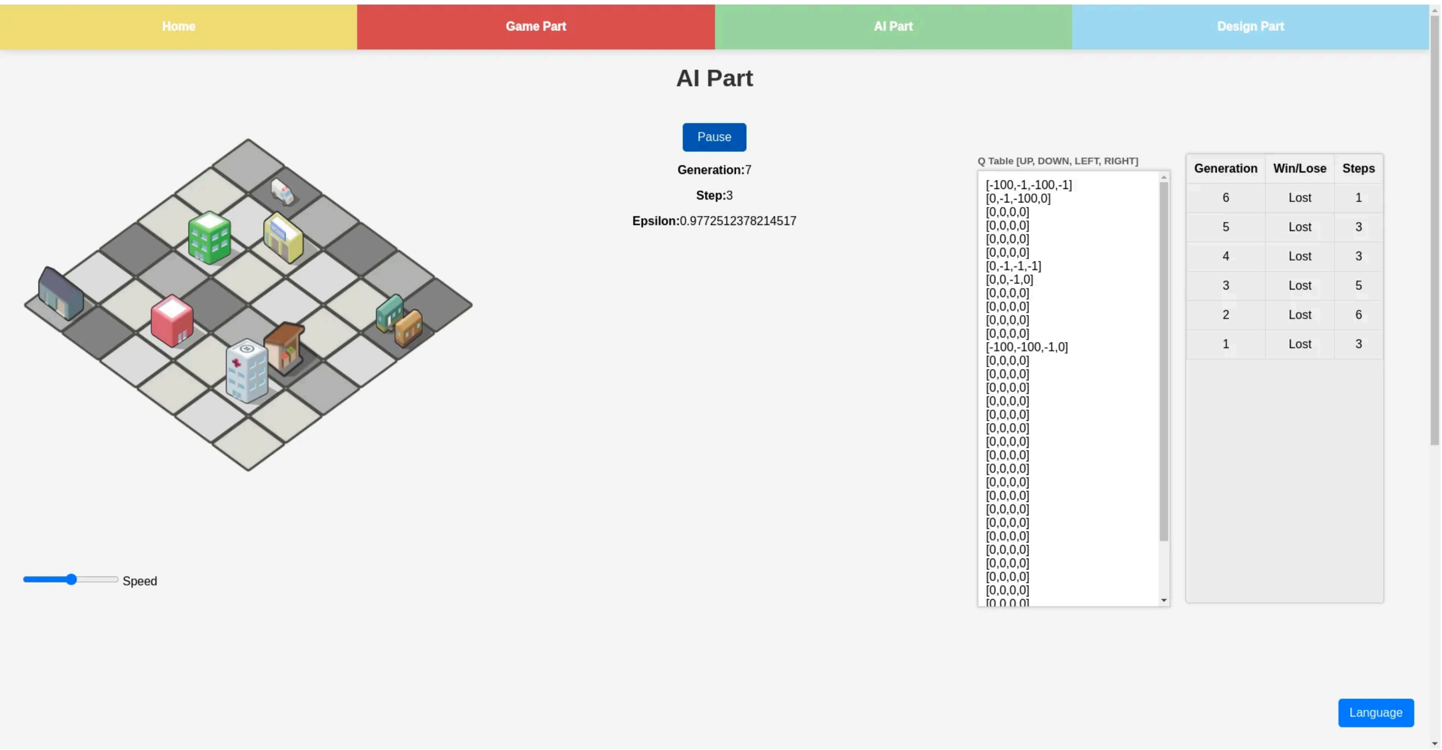
Background and description of the problem to be solved in this step: In this second step, students will explore how a machine learns using an online tool. The goal is to draw a parallel between their own trial-and-error learning experience and the way an artificial intelligence system tackles the same problem, highlighting the similarities and differences. The objective is for students to understand how AI uses a systematic approach to learning, relying purely on feedback without any pre-existing knowledge or intuition, much like their initial experience. By comparing human and machine learning, students will also observe how the iterative process differs between living beings and computational models, focusing on the efficiency and challenges in each approach.

Learning Objectives: Core Competencies: Understand the basics of machine learning and reinforcement learning, observe how machines learn from experience, and develop an appreciation of how feedback impacts learning in AI systems. Students will also learn about the different elements of reinforcement (both positive and negative) and how these contribute to building a learning model for the machine. **Auxiliary Competencies**: Learn to critically observe and compare human and machine learning, understand how positive and negative reinforcement affects learning, begin to see how AI models are built iteratively, and appreciate the power of computational learning in processing large amounts of data quickly to refine learning outcomes.

Conceptualisation

In this stage, students will use the online tool [BioLearningGame] to observe how an **AI agent** attempts to solve the same problem they worked on in Step 1. The AI starts with **no prior knowledge** of the objective, just like the students in the first step. It must learn by moving through the grid and receiving feedback for each action:

- **Positive Reinforcement**: When the AI makes a correct move, it receives **positive feedback**, reinforcing the actions that bring it closer to the goal. This is similar to the **satisfaction** that students felt in the first step when they found a move that worked well, pushing them in the right direction.
- **Negative Reinforcement**: Incorrect moves result in **negative feedback**, which the AI uses to understand which paths to avoid in the future. Just like the **frustration** or setback felt by the students when they encountered a wrong move, the AI adjusts its model to reduce the likelihood of repeating errors.



The teacher will explain that the AI's learning model, called a **reinforcement learning model**, is inspired by the trial-and-error approach. By observing the AI, students will see how it gradually learns to find the optimal path to the target through repeated failures and successes. This process mirrors human learning but on a more systematic and computational level.

To help students understand reinforcement learning more concretely, the teacher can provide an example using a scoring system. For each correct move, the AI receives a reward of **1 point**. When the AI reaches the goal, it earns a significant reward of **100 points**. If the AI encounters an obstacle, it receives a penalty of **-10 points**. The AI uses these rewards and penalties to update its model of the environment, a process called **Q-Learning**.

The Q-Learning Algorithm. The Q-Learning algorithm updates its model using the following formula:

$$Q(state, action) = Q(state, action) + learning\_rate * (reward + discount\_factor * max(Q(next\_state, all\_actions)) - Q(state, action))$$

Where:

- **Q(state, action)**: The expected utility of taking a given action from a given state.
- **learning_rate**: A parameter that controls how much new information overrides the old.
- **reward**: The immediate reward received after taking the action.
- **discount_factor**: A factor that determines the importance of future rewards compared to immediate rewards.
- **max(Q(next_state, all_actions))**: The maximum expected future reward attainable from the next state.

For example, if the AI moves to a new position and receives a reward of **1 point**, the Q-value for that state-action pair is updated to reflect this new information. If the AI hits an obstacle and receives a penalty of **-10 points**, it learns to avoid that path in the future by lowering the Q-value for that action. However, with this scoring function, the robot may not prioritize finding the shortest path since every normal movement has a positive value. To ensure the robot seeks the shortest route, a scoring function could include a minor penalty for each move, such as **-1 point per movement**, a penalty of **-100 points** for hitting an obstacle, and a reward of **100 points** for reaching the goal. This encourages the AI to minimize unnecessary movements while still aiming to reach the goal. The process continues iteratively, with each action refining the model.

The teacher can also illustrate that each move by the AI is driven by its attempt to maximize its cumulative reward—trying to get as much positive reinforcement as possible while minimizing the negative feedback. It is an iterative approach where each step is either a learning moment or a reinforcement of previous successful actions. This concept helps introduce how machines utilize experiences to improve, without the intuition that humans often rely on.

Students Investigation

In the investigation phase, students will actively observe and analyze the learning behavior of the AI on the BioLearning app. They can use the graph below the game board to understand the global process of learning.

The teacher should encourage them to make specific and detailed observations regarding the AI's learning process:

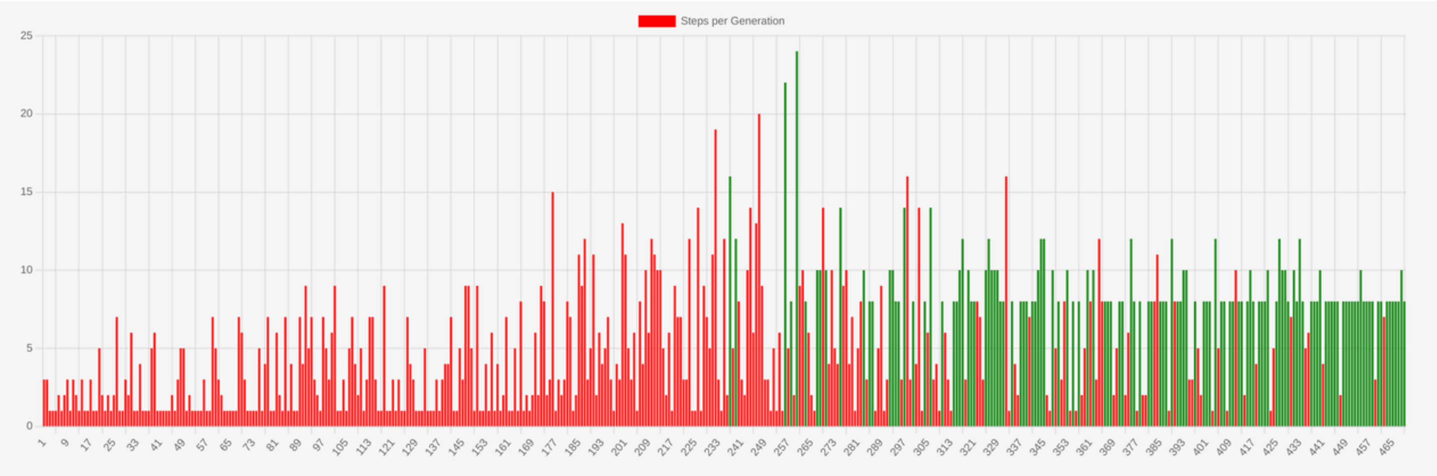
- **Comparison with Human Learning**: How does the AI's learning process compare to their own experience in Step 1? In what ways is it similar, and how is it different? Discuss both the similarities and differences in the methods and efficiency of learning.

- **Trial and Error Observation**: How many attempts did it take before the AI reliably found the goal? What role did positive and negative reinforcement play in guiding its decisions?

- **Path Optimization**: How long does it take the AI to find an optimal (shortest) path compared to the initial random exploration phase? In the BioLearning application, students should observe the initial attempts where the AI moves randomly, without any understanding of the environment, and then note the progressive improvement. How many iterations did it take before the AI was able to consistently reach the goal, and how long before it found the most efficient route?

- **Reinforcement Effects**: Observe how positive reinforcement (reaching the goal) and negative reinforcement (hitting obstacles) influence the AI's behavior. What patterns do they notice in how the AI responds to these reinforcements?

- **Adaptation and Improvement**: How does the AI adapt over multiple generations of learning? What changes in its strategy can be observed as it continues to learn?



The teacher will also facilitate discussions on **why the AI behaves differently compared to human learners**. Students should be encouraged to think about the advantages of computational learning, such as speed and the ability to test many paths without fatigue, versus the adaptability and intuition that humans bring to problem-solving tasks.

By focusing on these questions, students will better understand the systematic nature of AI learning, the role of trial and error, and how reinforcement mechanisms drive improvement over time.

Conclusion & Further Reflexion

- **Knowledge Mobilized**: By the end of this step, students will have developed a foundational understanding of reinforcement learning and its application in AI systems. They will understand that unlike humans, who may use intuition and context to navigate learning situations, machines rely on systematic feedback and numerous attempts to build a reliable model of their environment. Students will learn how the AI utilizes Q-learning to iteratively refine its decisions, ultimately leading to an improved strategy based on the rewards and penalties received.
- **General Learning Outcomes**: By the conclusion of this phase, students should have a clearer understanding of how reinforcement learning enables machines to learn through experience, and how this differs fundamentally from human learning. They will appreciate that while machines excel at processing large datasets and can perform exhaustive trial-and-error processes without fatigue, they lack the adaptability and intuition inherent in human learning. Conversely, they should recognize that humans can learn efficiently from fewer examples due to their ability to draw on prior knowledge and contextual understanding. Encourage students to think about how the combination of human intuition and machine processing power could lead to powerful synergies in problem-solving.

Reflecting on Reinforcement

Encourage students to reflect on how both positive and negative reinforcements shaped the learning process for both themselves and the AI. Discuss why positive reinforcement (e.g., rewards for achieving the goal) and negative reinforcement (e.g., penalties for hitting obstacles) are equally essential for learning. Highlight the idea that learning, whether human or machine, requires both encouragement and the identification of mistakes to refine understanding and improve outcomes over time.

The Concept of Efficiency

Discuss how the AI's goal evolved over time—from simply reaching the target to finding the most efficient path to the destination. Initially, the AI's objective is to learn how to achieve success, but as it gains experience, it starts to optimize its approach by seeking shorter, more efficient paths. This is similar to how humans refine their learning to become more efficient at tasks after gaining a fundamental understanding. Emphasize that efficiency is often a secondary but vital goal in both human and machine learning.

Understanding Iterative Improvement

Discuss with students how the AI improves its model iteratively. At first, it moves almost randomly, but over successive iterations and with the reinforcement of feedback, it begins to make more informed decisions. This mirrors the human learning process where repeated practice leads to mastery. In the BioLearning tool, students can observe how the AI's paths initially are inefficient but gradually become more direct as the AI learns from both positive and negative experiences.

Comparison Between Human and Machine Learning

Facilitate a discussion around the differences between human and machine learning. While humans can often make intuitive leaps and adapt quickly based on past experiences, machines require explicit feedback and many iterations to learn. Highlight that humans can generalize from one experience to another much faster, whereas machines need systematic data and reinforcement to build their model from scratch. This comparison helps students appreciate the unique strengths and limitations of both types of learning.

Opening discussions for Concluding on Step 2

To conclude this step, students will be invited to discuss the following questions:

1. How did the machine's learning approach compare to yours in Step 1, and what do you think are the strengths and weaknesses of the AI's approach to learning?
2. Why do you think the AI needed more or fewer attempts to learn the correct path compared to the students, and how important was trial and error for the AI to find the goal, and why?
3. How does the concept of reinforcement help both humans and machines in improving their performance, and how did the AI deal with incorrect moves, using that information in subsequent attempts?
4. If the goal changed, how do you think the machine would react compared to a human, and what can we learn about human adaptability by comparing it to the machine's learning process?
5. In what ways is the AI's approach bio-inspired, and how does it mimic natural learning processes?
6. What kinds of tasks might be more suitable for AI learning versus human learning, and why?

Step 3 - Adaptability of humans vs. machines

Background and description of the problem to be solved in this step: In this final step, students will explore the adaptability of both humans and machines in a changing environment. The challenge is to understand how humans can leverage intuition, previous experiences, and adaptive strategies when faced with unexpected changes, compared to an AI that must rebuild its model from scratch. This comparison aims to highlight the strengths and weaknesses of both types of learning.

Learning Objectives:

- **Core Competencies**: Understand the concept of adaptability in learning, compare human flexibility with machine learning capabilities, and explore how both react to changes in their environment.
- **Auxiliary Competencies**: Develop critical thinking by analyzing the differences in learning strategies, improve problem-solving skills by navigating a modified environment, and engage in collaborative learning through group activities.

Conceptualisation

In this stage, students will conceptualize how adaptability plays a crucial role in learning, whether in humans or machines. The focus will be on exploring how humans utilize past experiences and intuition to adjust their actions, compared to the AI's need to rebuild its learning model when facing changes in the environment. To facilitate this, students will work in small groups to define what adaptability means in both biological and technological contexts.

- **Establishing Hypotheses**: Students will begin by hypothesizing how they believe humans and machines might adapt to unexpected changes in a given environment. They will discuss questions like: "How might an AI react if the goal location changes unexpectedly?" or "What strategies do humans use when they realize their original plan is no longer effective?" These hypotheses will serve as the foundation for experimentation and subsequent analysis.

- **Redefining the Environment**: The students will be split into two groups. One group will modify the original map of the city (representing the AI's environment) by changing the starting point, altering obstacles, or moving the goal. The second group will need to navigate the modified map, just like in the initial exercise. Students will not be able to see the changes beforehand, simulating an unexpected shift in the environment.

- **Understanding Learning Models**: Teachers will introduce the idea of a learning model for both humans and machines. For machines, this means retraining or updating the AI model using new data to adapt to changes, while for humans, this involves using experiences and applying previous knowledge intuitively. Teachers should emphasize how AI needs explicit retraining, whereas humans often adapt more fluidly using their intuition.

- **Critical Analysis**: Throughout this conceptualization stage, encourage students to critically analyze the differences between human adaptability and machine adaptability. Questions like "What makes humans more adaptable in certain situations?" and "How does the AI approach differ fundamentally from human decision-making?" will help deepen their understanding.

Students Investigation

<u>**Adaptability of Human**</u>

In the investigation phase, students will put their hypotheses to the test by engaging in a hands-on activity. The students will be split into two groups, each having distinct roles to simulate a dynamic learning environment:

- **Group 1: Map Designers**: Group 1 will be tasked with creating a new city map by modifying the placement of obstacles and starting point, and moving the goal to a different location. It will act similarly to the teacher in Step 1, giving directions and providing feedback. As the game proceeds, they will assign rewards and penalties based on the other group's actions, mimicking how the AI received feedback during its learning process.

- **Group 2: Navigators**: Group 2 will be responsible for navigating the newly modified map. They will attempt to find the optimal path to the goal by learning through trial and error, relying on the feedback given by Group 1. Their task is to accumulate as many points as possible while trying to determine the best route. By successively attempting different paths, they will incrementally learn to identify the successful strategy and aim to find the shortest route to the target.

Once the activity is completed, the groups will switch roles. This will provide all students with the opportunity to experience both aspects of adaptability—making modifications to an environment and adapting to unexpected changes without prior knowledge.

Adaptability of Machine

After completing the hands-on exercise, students will then proceed to model their modified map using the "Design" tab of the BioLearningGame application. They will input the changes they made during the hands-on exercise to create a virtual version of the environment. The AI will then attempt to adapt to the new layout, demonstrating how it approaches the problem compared to human learners.

Students should carefully observe how the AI handles the new environment. Initially, the AI will perform poorly, moving randomly without any clear strategy, similar to how Group 2 initially navigated the new map. However, as more iterations occur, the AI will start learning from the feedback it receives, eventually finding the goal.

Comparaison

One key insight students should gain from this exercise is that the AI initially learned a specific route to the goal in the original environment. When the map changes, the AI must essentially relearn from scratch, treating it as a new problem. This highlights a fundamental difference between human and machine adaptability. Humans are capable of using prior knowledge to adapt relatively quickly, while an AI often has to reset its learning and begin anew when faced with significant environmental changes.

This investigation phase will help students develop a nuanced understanding of the limits of machine learning and appreciate the unique adaptability of human cognition.

In this stage, students will conceptualize how adaptability plays a crucial role in learning, whether in humans or machines. The focus will be on exploring how humans utilize past experiences and intuition to adjust their actions, compared to the AI's need to rebuild its learning model when facing changes in the environment. To facilitate this, students will work in small groups to define what adaptability means in both biological and technological contexts.

Conclusion & Further Reflexion

- **Knowledge Mobilized**: By the end of this step, students will have a clear understanding of the concept of adaptability, both in humans and machines. They will recognize that while humans can draw on previous experiences and intuition to adapt quickly to changes, machines must systematically relearn when confronted with a modified environment. This distinction highlights the different mechanisms underlying human and machine learning, emphasizing how machines rely on structured retraining processes compared to human improvisation and experience-based adaptation.
- **Classroom Implementation Reflection**: Finally, provide an opportunity for students to reflect on their own experience of adapting to the map changes and compare it with how the machine adapted. How did it feel to have to find a new solution in an environment where the rules had changed? What did they learn about the differences between human and machine problem-solving abilities? This reflection helps solidify the learning objectives of adaptability, critical thinking, and understanding the underlying mechanics of reinforcement learning in both humans and machines.

Human vs. Machine Adaptability

Facilitate a discussion to explore how humans managed to adapt to the changes in the environment versus how the AI reacted. What differences did students notice in the learning strategies used by humans compared to the machine? Discuss how humans were able to use their prior knowledge to adjust more efficiently, whereas the AI had to go back to a "blank slate" in a sense when learning the new environment.

Reinforcement and Iterative Learning

Reinforce the concept of positive and negative reinforcement in both human and machine contexts. Highlight how Group 2 (navigators) relied on the feedback (rewards or penalties) from Group 1 to gradually improve their pathfinding. Compare this with how the AI relies on reinforcement signals to update its model and progressively find an optimal route. Emphasize how iterative learning, whether through human experience or machine calculation, requires both reinforcement types to guide behavior effectively.

Limitations and Opportunities

Lead a discussion on the limits and strengths of machine learning. Why does the AI struggle to adapt as effectively as humans when the environment changes? What are the benefits of having machines that can carry out thousands of iterations without fatigue? Encourage students to think about potential improvements to AI systems that could enable them to adapt more fluidly, for example, by retaining some form of generalizable knowledge instead of starting over completely.

Practical Applications

Ask students to reflect on practical applications of the concepts learned. How does adaptability manifest in real-world AI systems, such as navigation software, autonomous vehicles, or personal assistants? What are the challenges faced by these systems when the context or environment changes? This discussion will help students connect the activity to everyday technologies and develop a greater appreciation for the complexity of machine learning.

Opening discussions for Concluding on Step 3 and Going Further

To further deepen understanding, conclude the activity with a set of open discussion questions. These questions are designed to encourage students to think critically about the concepts covered and relate them to broader contexts:

1. How do humans adapt to unexpected changes differently compared to machines? What role does prior experience play in human adaptability, and why is it challenging for machines?
2. How could reinforcement learning be improved to make machines adapt more efficiently to new environments, and why is both positive and negative reinforcement necessary in learning processes?
3. What challenges do AI systems face in adapting to new situations, and how could these challenges be mitigated?
4. Can you think of examples in your daily life where adaptability is important? How do humans manage these situations?
5. How does an AI's inability to generalize from prior learning affect its performance in real-world applications? What are some potential dangers of machines needing to relearn from scratch each time their environment changes?
6. How can human creativity and machine learning complement each other in solving complex problems? What might the future hold for AI systems in terms of improving adaptability, and what areas need the most focus for development?

Bibliography

For teachers wishing to explore the concept of reinforcement learning and its bio-inspired dimension in more depth, the following resources are recommended:

- **Books:**
  - *Reinforcement Learning: An Introduction* by Richard S. Sutton and Andrew G. Barto - This is an excellent resource for understanding the fundamentals of reinforcement learning, with numerous examples demonstrating how an agent learns through trial and error.
  - *The Book of Why: The New Science of Cause and Effect* by Judea Pearl - This book provides insights into the importance of causality in learning, including reinforcement learning.

- **Academic Articles:**
  - A Survey of Reinforcement Learning Techniques - Offers a broad overview of different techniques and concepts associated with reinforcement learning.
  - Reinforcement learning in artificial and biological systems - Explores how reinforcement learning techniques are inspired by biological models, particularly animal behavior.

- **Online Courses:**
  - Coursera - Fundamentals of Reinforcement Learning - An interactive course that introduces key concepts of reinforcement learning, offered by the University of Alberta.
  - edX - Artificial Intelligence (AI) - This general AI course includes an introduction to reinforcement learning, explained with practical examples.

- **Educational Videos:**
  - Deep Reinforcement Learning: Pong from Pixels - A video that illustrates how AI learns to play Pong, showing how positive and negative reinforcement affects an agent's decisions.
  - How does artificial intelligence learn? - A short, engaging video explaining how machines learn, including the principles of reinforcement learning.

- **Websites and Blogs:**
  - AI Unplugged - Gather in one document several unplugged activities and teaching material on artificial intelligence.
  - Machine Learning Unplugged - The Tech Interactive - Unplugged activity to discover machine learning through visual recognition.
  - OpenAI Blog - Features educational and accessible articles explaining reinforcement learning and its use in developing advanced AI.
  - DeepMind Blog - Explores how reinforcement learning is used to solve complex problems, drawing inspiration from how the human brain works.
  - Teaching machines to behave: Reinforcement Learning - This article provide and entry point for anyone into Reinforcement learning. It provide the fundamentals necessary to comprehend what Reinforcement Learning algorithms are, how they work
  - Deep Reinforcement Learning: Pong from Pixels - This article presents an example of Deep Reinforcement Learning application by developing an agent that can play Pong.

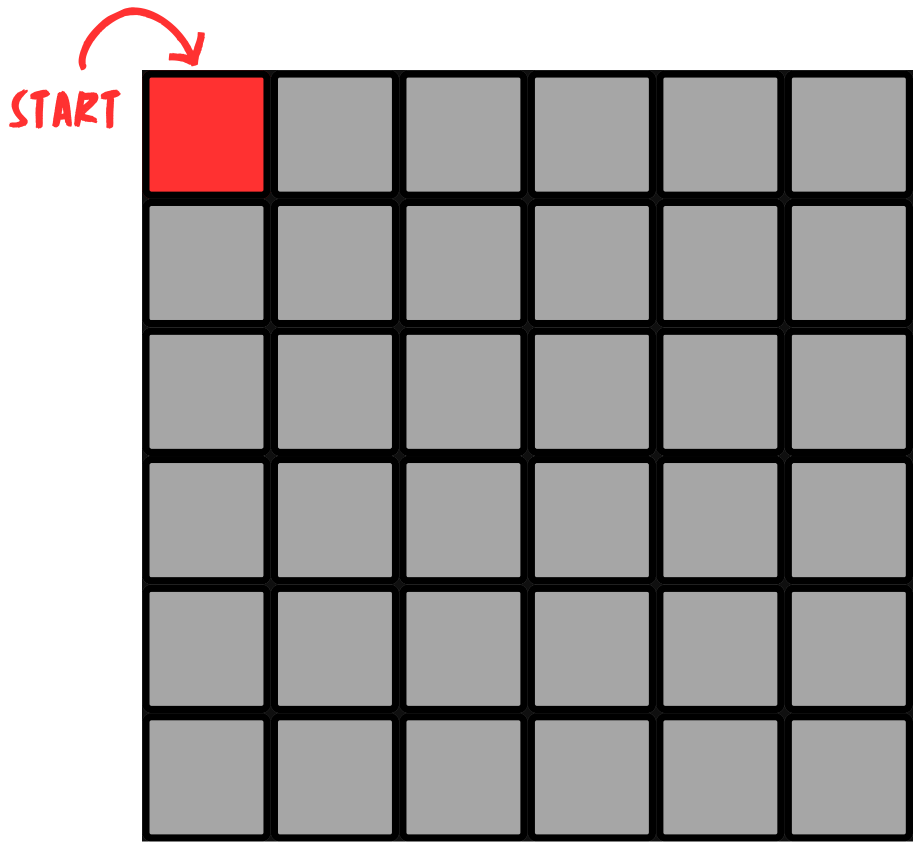
- **Simulation Platforms:**
  - OpenAI Gym - A platform that allows teachers and students to experiment with reinforcement learning in simulated environments, providing hands-on experience.
  - BioLearningGame - The tool already mentioned in the activity, which allows visualization of how a machine model learns from scratch using positive and negative reinforcement.

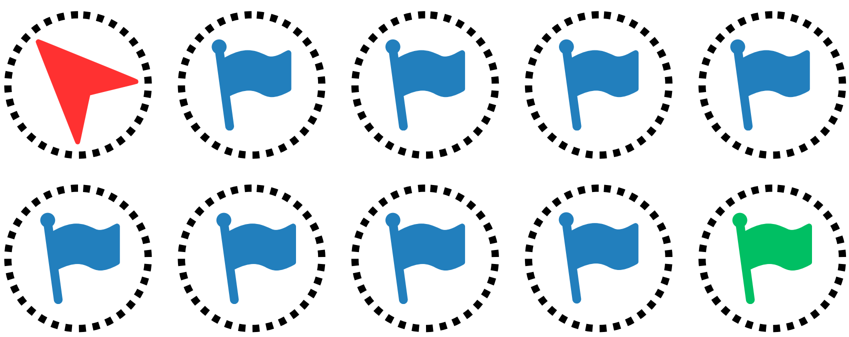
These resources will help teachers to deepen their understanding of reinforcement learning and its biological inspirations, enabling them to enrich the activities offered to students.

DISCOVER AI

The map

STUDENTS

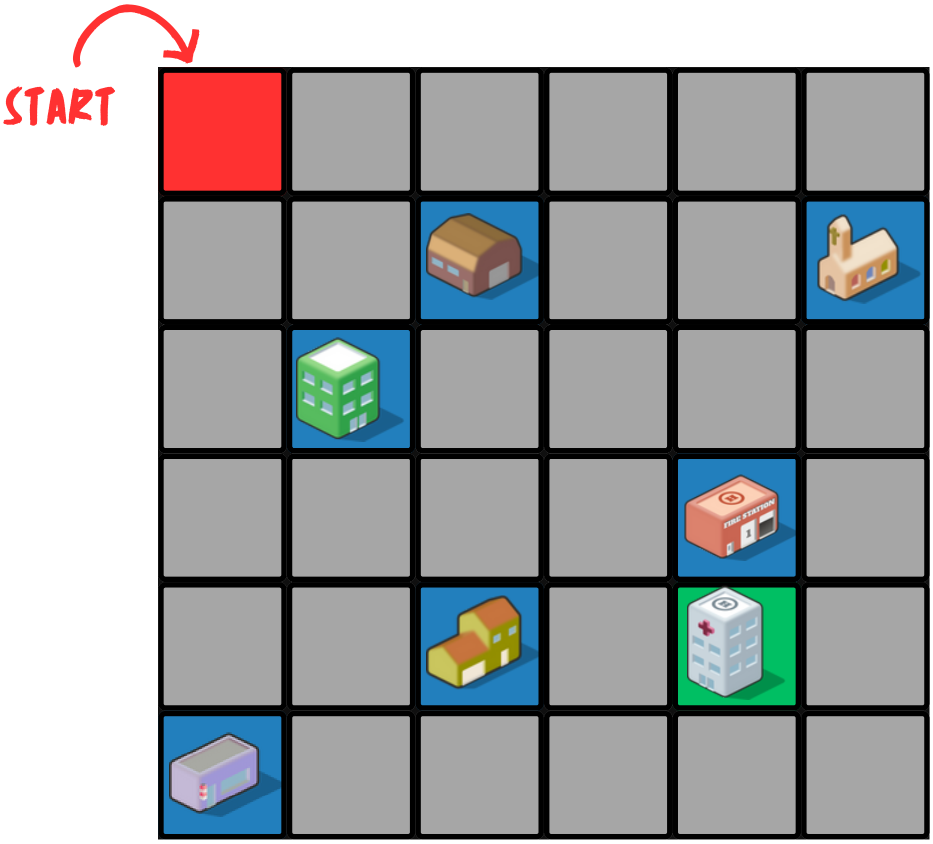


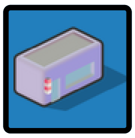


DISCOVER AI

The map

TEACHERS





: BUILDINGS

: HOSPITALS