

Using Scratch to Teach 21st Century Scientific Thinking Skills

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21st Century Scientific Thinking

- Systems Thinking:** Thinking with an awareness of complex causal system
- Mechanistic Thinking:** Thinking with a mechanical or engineering undertone
- Interdisciplinary Thinking:** Thinking flexibly across different disciplines
- Quantitative Thinking:** Thinking with mathematics
- Distributed Thinking:** Thinking beyond the individual mind to involve other persons or technology

Role of Digital Technology

- Three major reasons behind why digital technology should be used to teach 21st century scientific thinking skills:
- 1) Situated Learning:** Learning is situated in the same digitally rich culture in which the thinking skills are developed and used by the scientific community
 - 2) Creative Thinking:** Digital technologies lend well to support creative thinking
 - 3) Digital Fluency:** Digital fluency is critical in our media-rich participatory culture

Scratch Lessons for Mechanistic Thinking

- 1) Help students understand how modern scientists think mechanistically
- 2) Have practice thinking mechanistically by simulating how synthetic biologists think in the field
- 3) Help students recognize mechanistic thinking even when it is not in the context of science, as in their own work via Scratch.



How are scientists thinking mechanistically in the 21st century?

Understanding Goals

- ◆ The rapid advancement of technology and the accumulation of information are changing the patterns of scientific thinking and research in the 21st century.
- ◆ Designing and creating novel organisms by combining various biological components from different cells is one way scientists think mechanistically in the 21st century.
- ◆ Designing and creating Scratch projects using graphical programming blocks is one way students can display mechanistic thinking.
- ◆ Identifying characteristics of successful scientist and their thinking patterns, help us become better (science) students by applying these skills to our own learning.

Background Information

Beyond the Scientific Method

The scientific method has been common only correct way to conduct scientific that all of science proceeds in much in accurate. Perhaps some scientists might it in the stereotyped, step-by-step way scientists report their work in this way

In fact, scientists throughout history co approach a scientist uses depends on its particular question or problem being its patterns that are specific to its particular

21st Century Scientific Thinking Skills
With the explosion of advancements in century, scientists at the cutting edge of their work. Five prominent scientific thinking, interdisciplinary thinking

Mechanistic Thinking
It is a way of thinking that has a mechanistic scientists' modular, synthetic, and purpose. Due to recent developments in new techniques manipulate biology more directly, allowing for practical applications.

¹ Liu, Y. D., & Gomez, T. A. (2009). Learning beyond skills. M. S. Khan (Ed.), *Personalized learning* (pp. 9-36). Rotterdam, Sense Publishers.

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Lesson Plan: Day 1

- Materials**
- Computers with Scratch installed
 - Scratch Resources

Prep Step

- Review lesson plan, background information and understanding goals
- Obtain computers with Scratch Resources (not provided)
- Make copies of Scratch Resources

Explore

Step 1: Introduction to lesson

Introduce the lesson by giving students a sense of what they will be doing and where they are headed, by telling students, "This will be a three-day lesson where we will be exploring how scientists think, and more specifically what mechanistic thinking looks like in practice. In this process, we will also be learning Scratch. We will be everything together at the end of the third day."

Step 2: Playing with Scratch

Depending on the level of your students and any future goals you wish to achieve with Scratch, structure the class so that students are comfortable navigating around the Scratch environment and are able to get started on their own Scratch project by the end of the lesson. In this lesson, students will explore what

- Having Fun with Computer Programming and Games (http://www.kitware.com/learn/scratch/scratch.html)
- A TeachNetUK Project: 6 Lessons on Getting Started with Scratch (http://www.teachnetuk.org.uk/2007/02/scratch/)
- Scratch Lessons: Shall We Learn Scratch Programming for Kids (http://www.shallwelearn.com/scratchprogrammingfor-kids/)
- Scratch Lessons: A Creative Introduction to Scratch (http://www.creative-intellect.com/scratch/index.html)
- Designing Animations and Games—A Creative Introduction to Scratch (http://www.creative-intellect.com/scratch/index.html)

Make sure to also introduce students to the Scratch online community where they can download the source code of any project to help them see how others have used Scratch programming language to create projects.

Review, Extend, and Apply

Step 3: Scratch Assignment
End the day by informing students that they will apply what they have learned about the field of synthetic biology in their Scratch project for an assignment after the next day's lesson. Emphasize to students that the goal is not to create a complex programming project, but to use Scratch as a tool to explore and understand the field of synthetic biology. Encourage students to be creative in their designs and to use Scratch on their own time, and make it clear that you highly encourage them to share their Scratch projects with others (this is not considered cheating).

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New Media Literacy Skills	21 st Century Scientific Thinking Skills
Play	Systems Thinking
Performance	Quantitative Thinking
Simulation	Mechanistic Thinking
Appropriation	Mechanistic Thinking
Judgment	Interdisciplinary Thinking
Transmedia Navigation	
Negotiation	
Distributed Cognition	Distributed Thinking
Collective Intelligence	
Multitasking	
Networking	

Lesson Plan: Day 2

- Materials**
- Designing a New Microbe worksheet
 - Organism cards
 - Student notebooks or journals

Prep Step

- Review lesson plan, background information and understanding goals
- Obtain organism cards (each group of 4-6 students will have a set of cards) (p.29)
- Review lesson plan, background information and understanding goals
- Obtain organism cards (each group of 4-6 students will have a set of cards) (p.29)
- Cut out organism cards

Explore

Step 1: Designing a New Microbe

Introduce today's activity by saying, "You will be simulating how synthetic biologists think mechanistically by doing an activity that is actually modeled after a real experiment done by scientists in 2007."

Divide students into groups of 3 or 4. Each group receives a set of organism cards. Each student receives a *Designing a New Microbe* worksheet. Remind students that proteins (or enzymes) are how is converted to the molecule *How by Protein T in bacteria*.

Following the directions of the handout, have students create a kind of assembly line that ultimately produce hydrogen (output).

There are two possible pathways that can lead to hydrogen production:

1. Starch & water → Protein G → Protein P → Protein D → Protein H → Hydrogen
2. Starch & water → Protein G → Protein D → Protein H → Hydrogen

Guide students along by encouraging students who have already figured out how to attempt the problem to reveal and share with the class how they are thinking through the problem. Stop periodically to ask, "How are you thinking through this problem? What is your goal, sequentially forward or backward to fill in the worksheet to be easier."

Note to teachers: The hydrogen production pathway from starch and water is a shorter version of the actual 2007 experiment. The organism types and molecular names are nice to the experiment. Protein names are made up for simplicity.

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Lesson Plan: Day 3

- Materials**
- Designing a New Microbe worksheet
 - Organism cards
 - Student notebooks or journals

Prep Step

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Explore

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Lesson 1

Familiarize students with Scratch programming language. At this point, Scratch presented simply as medium for creative expression.

Lesson 2

Expose students to creative field of synthetic biology to illustrate how scientists think mechanistically via case study of Jay Keasling, one of the pioneers of synthetic biology. Analyzing how modern scientist work and think provide students with broader view of scientific inquiry.

Ask students to demonstrate their understanding of what they have learned so far by creating a Scratch project.

Lesson 3

Have students practice thinking mechanistically by simulating how synthetic biologists think in the field via activity adapted from actual synthetic biology experiment (designing a microbe that can use starch and water to make hydrogen gas).

Have students reflect on experience with Scratch, and recognize they have been engaging in mechanistic thinking while working on their own Scratch projects. Encourage students to transfer their understanding of mechanistic thinking across different domains. Gain an appreciation of how studying trends in scientists' way of thinking can help students in their own thinking.

Possible findings from case analysis: Jay Keasling in their journals/notebooks.

Keasling is a pioneer of synthetic biology—a field that designs organisms for useful purposes. He is most known for creating drug to treat malaria (killing drugs from bugs). Some of his include:

- Creative and imaginative: wanted to invent new chemical plants, make in something very simple and valuable, coming up with other applications
- Critical thinking: thought about how to design to break down molecules, make biodegradable
- Attention to detail: much quicker and cheaper, how to into a microbe to elaborate the drug

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