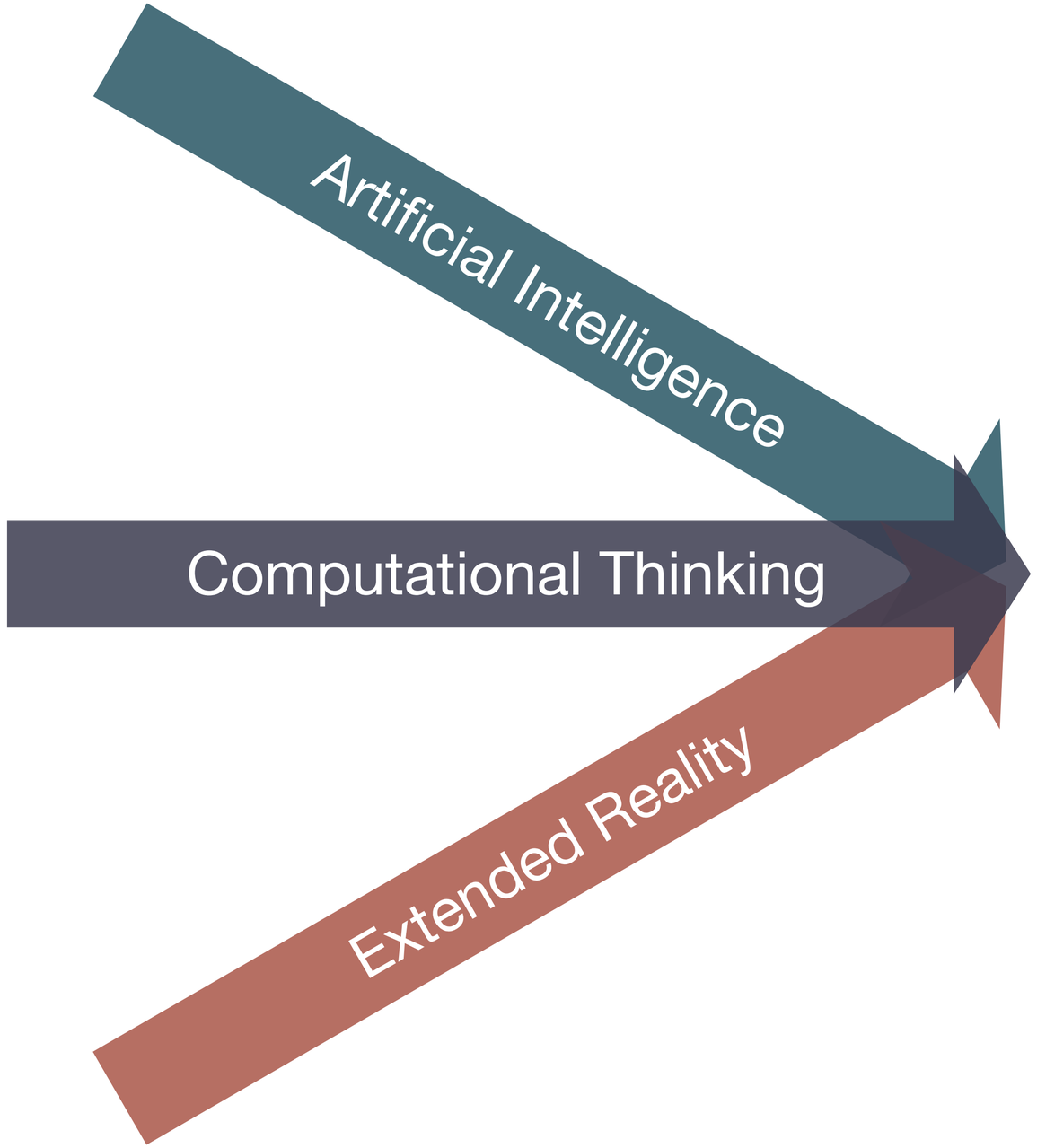
Healing Structures:
Weaving Technology into Medical Education

Ruben R. Puentedura, Ph.D.

Taxonomy of AI (e.g. Russell & Norvig 2011)

Dimensions of CT (e.g. Brennan & Resnick 2012)

Taxonomy of XR (e.g. Milgram & Kishino 1994)

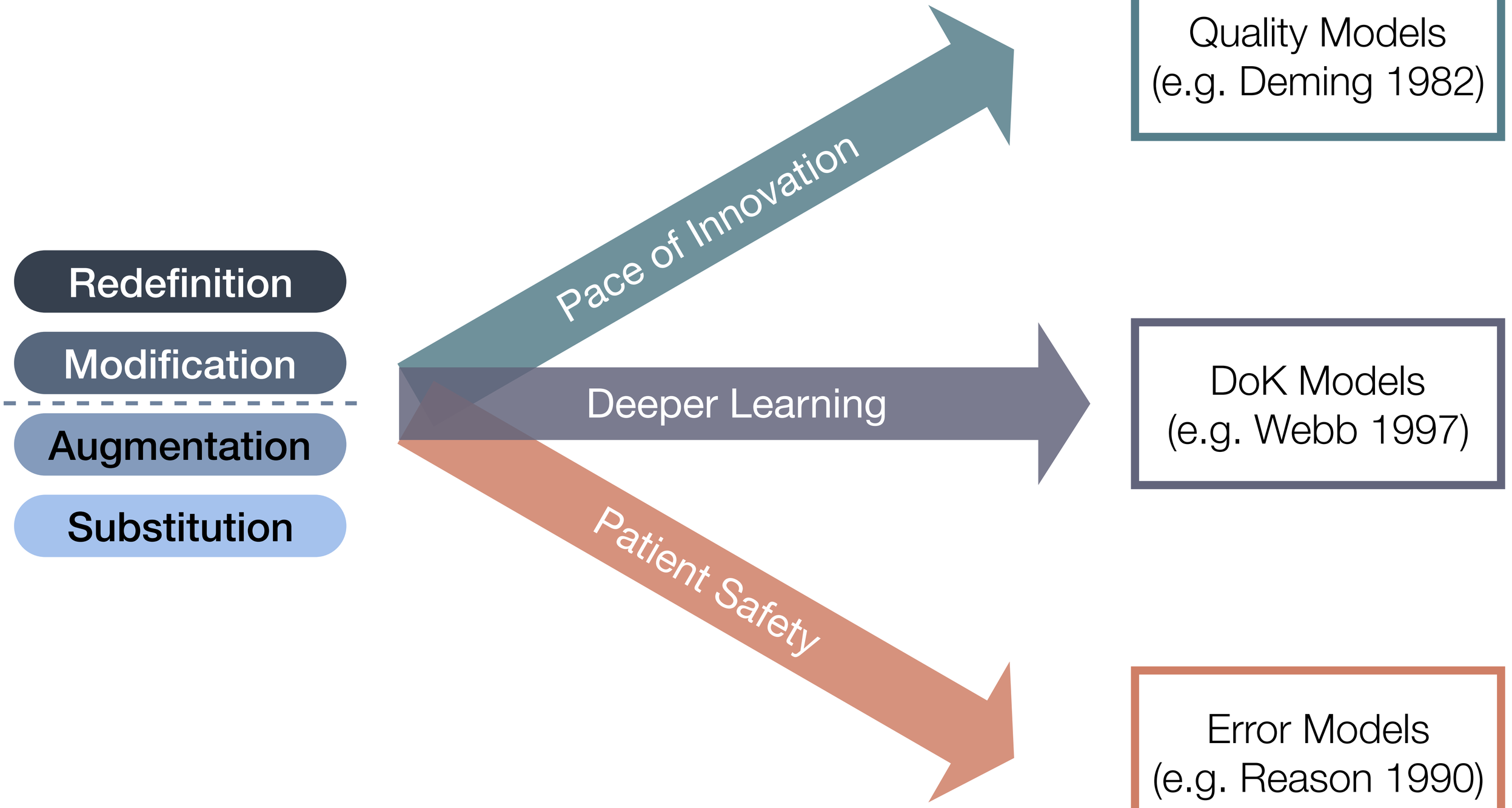


Redefinition

Modification

Augmentation

Substitution


Redefinition
Modification
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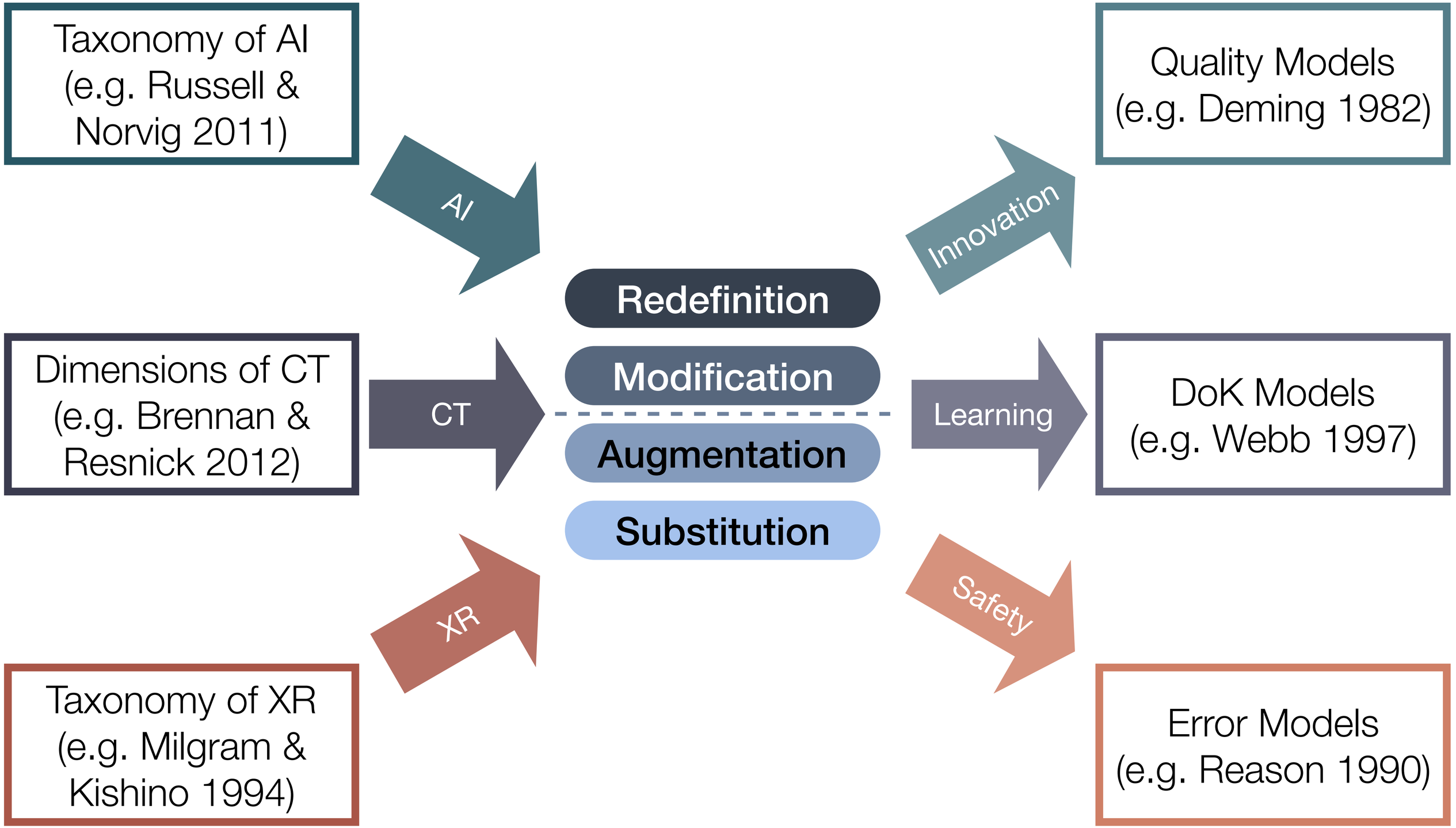
Pace of Innovation
Deeper Learning
Patient Safety
Quality Models
(e.g. Deming 1982)
DoK Models
(e.g. Webb 1997)
Error Models
(e.g. Reason 1990)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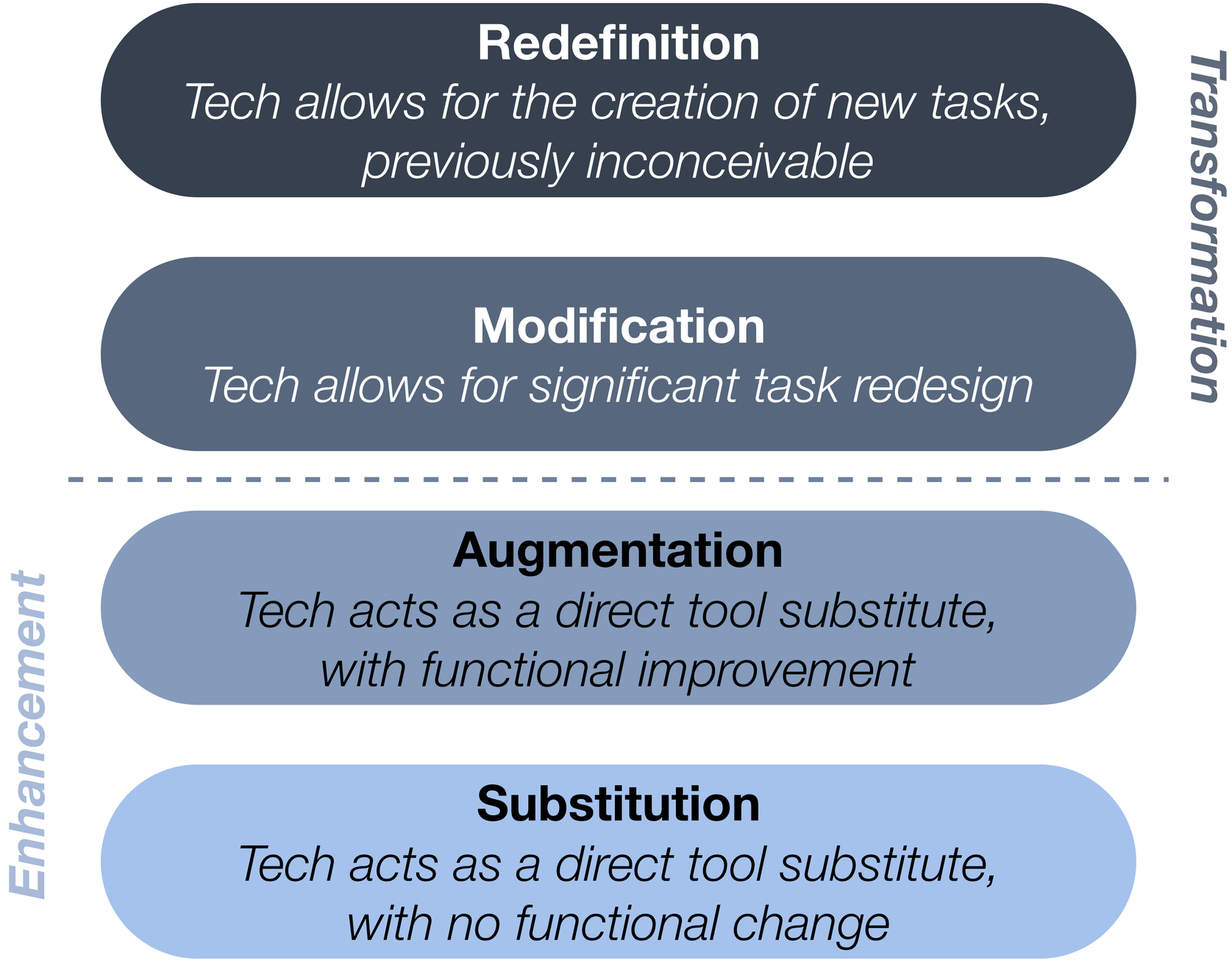

Ruben R. Puentedura, *As We May Teach: Educational Technology, From Theory Into Practice*. (2009)

Redefinition

Tech allows for the creation of new tasks, previously inconceivable

Modification

Tech allows for significant task redefinition

Augmentation

Tech acts as a direct tool substitute, with functional improvement

Substitution

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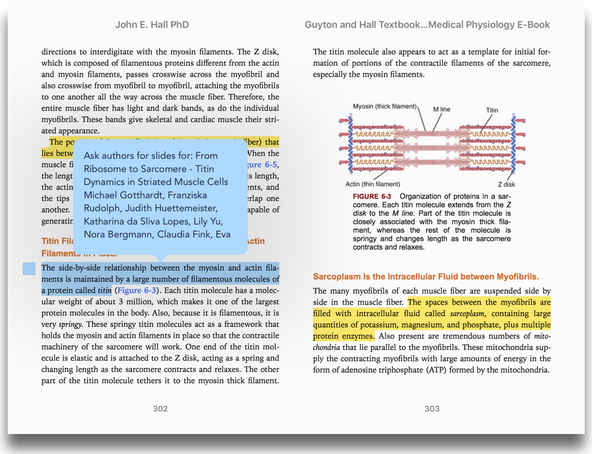

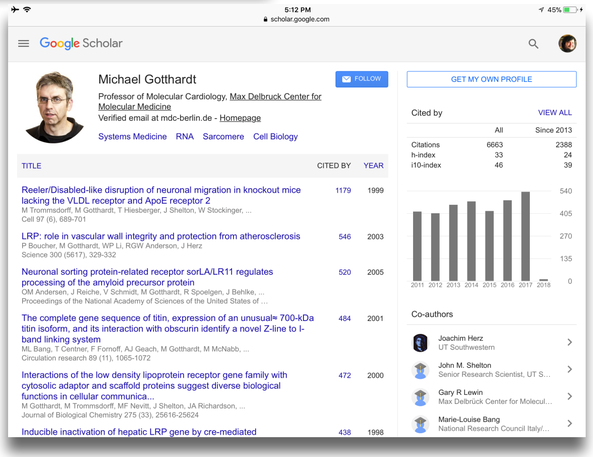

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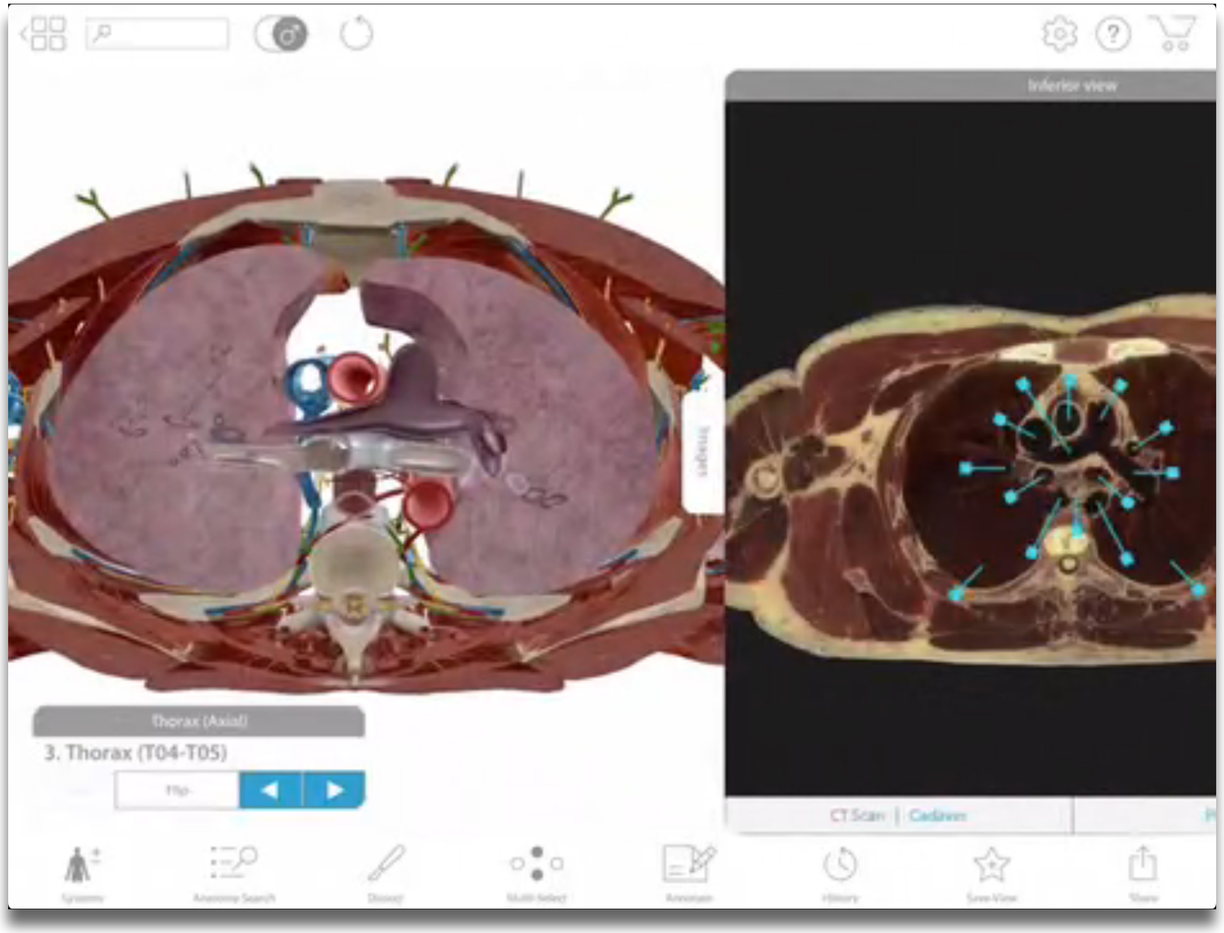

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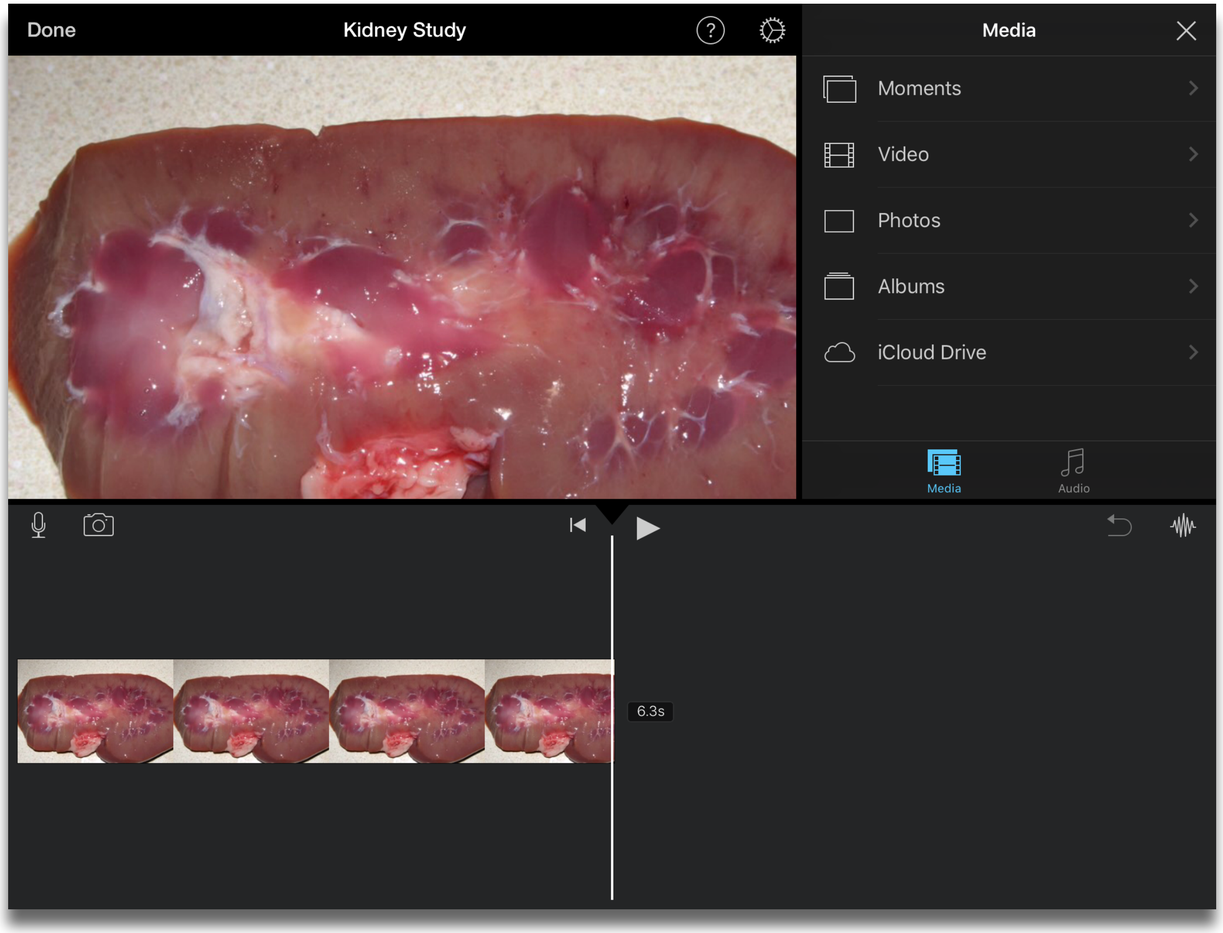

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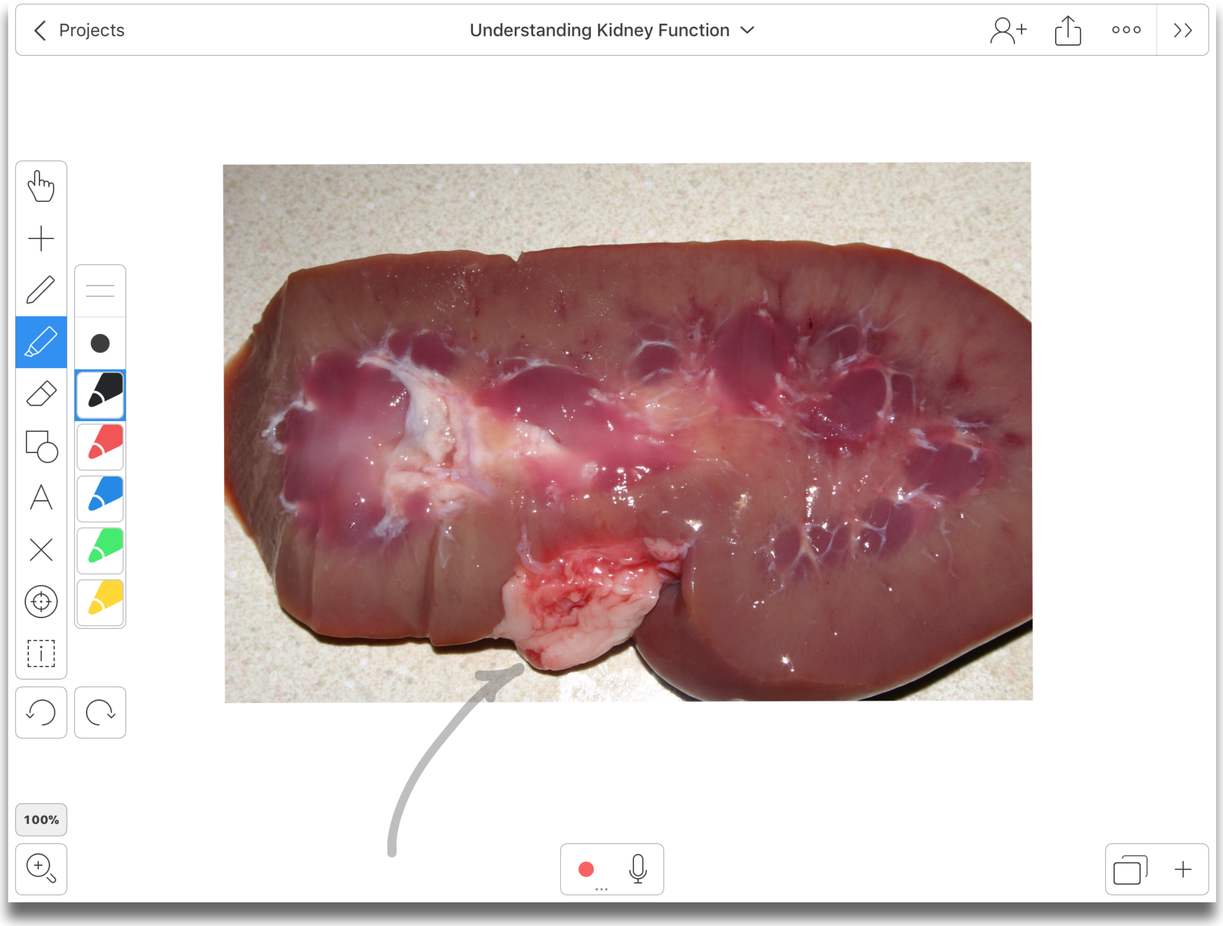
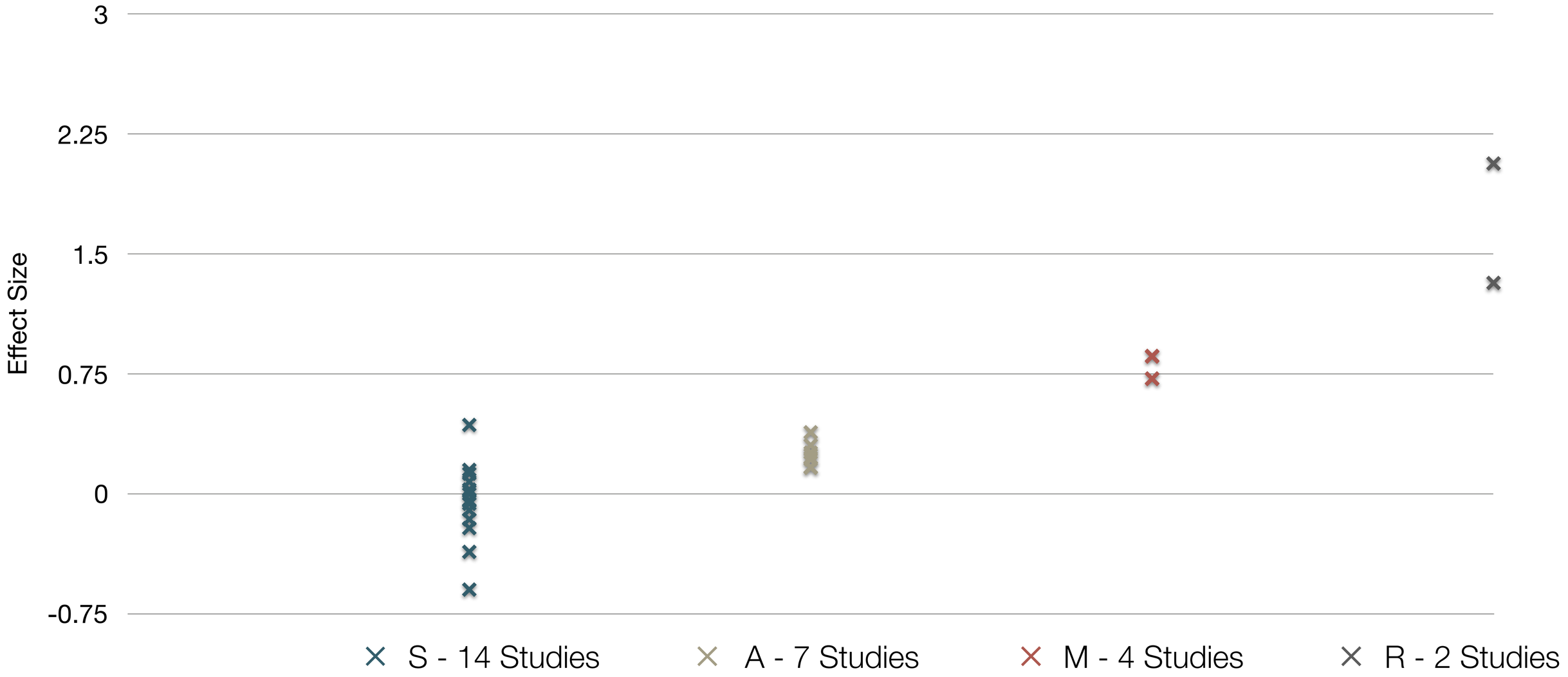


SAMR and the Use of Tablets in Education



Tamim, R.M., Borokhovski, E., Pickup, D., Bernard, R.M. & El Saadi, L. “Tablets for Teaching and Learning: A Systematic Review and Meta-Analysis." *Commonwealth of Learning (COL)* (2015).

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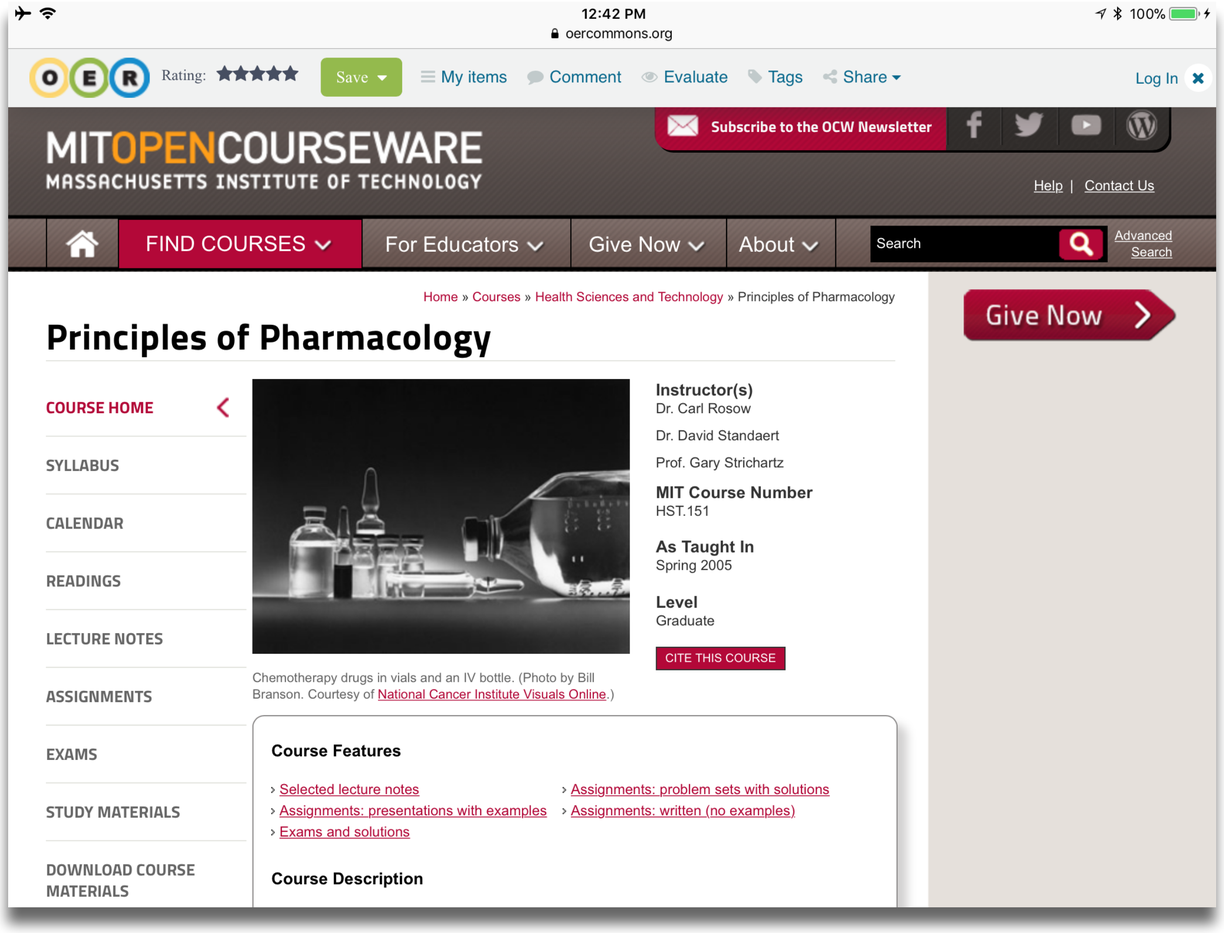

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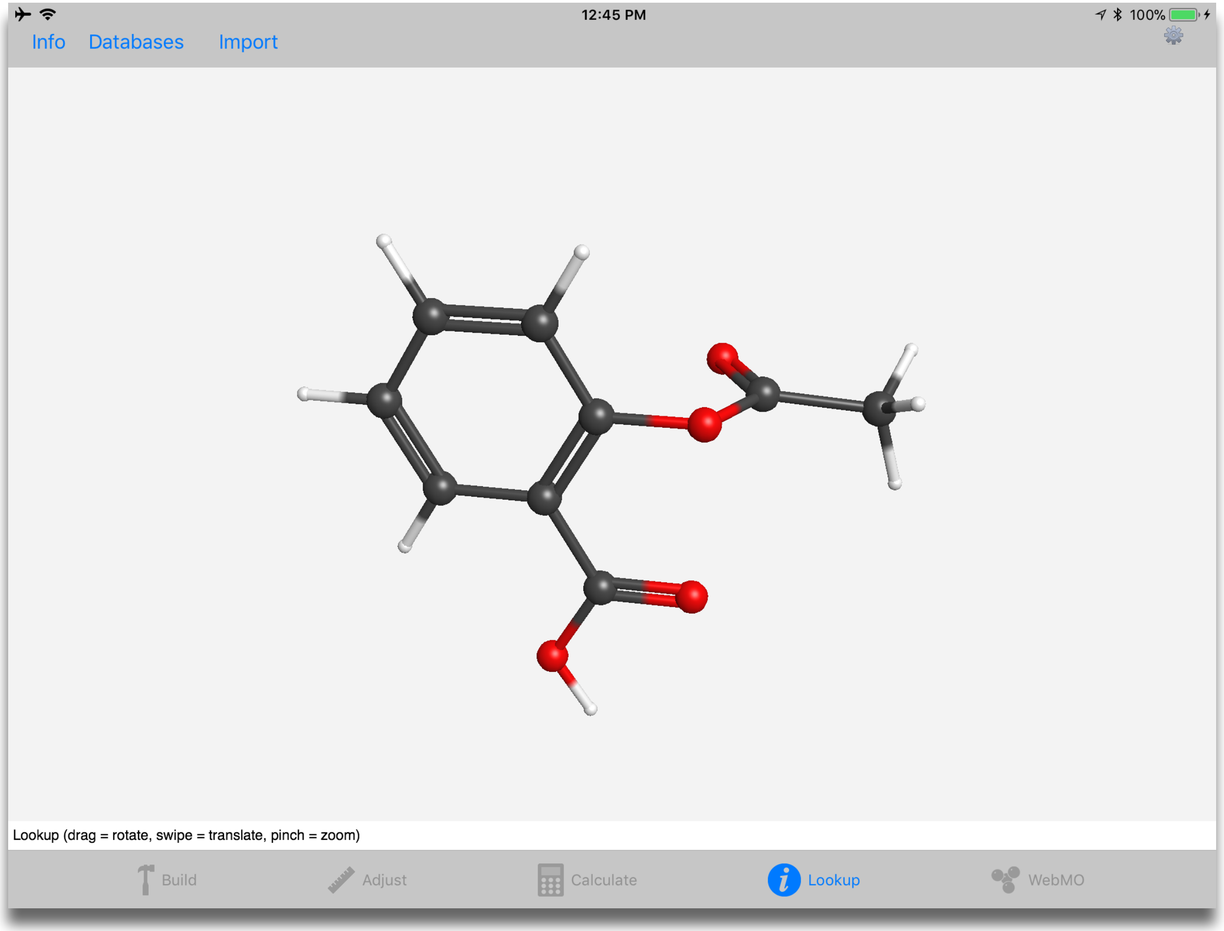

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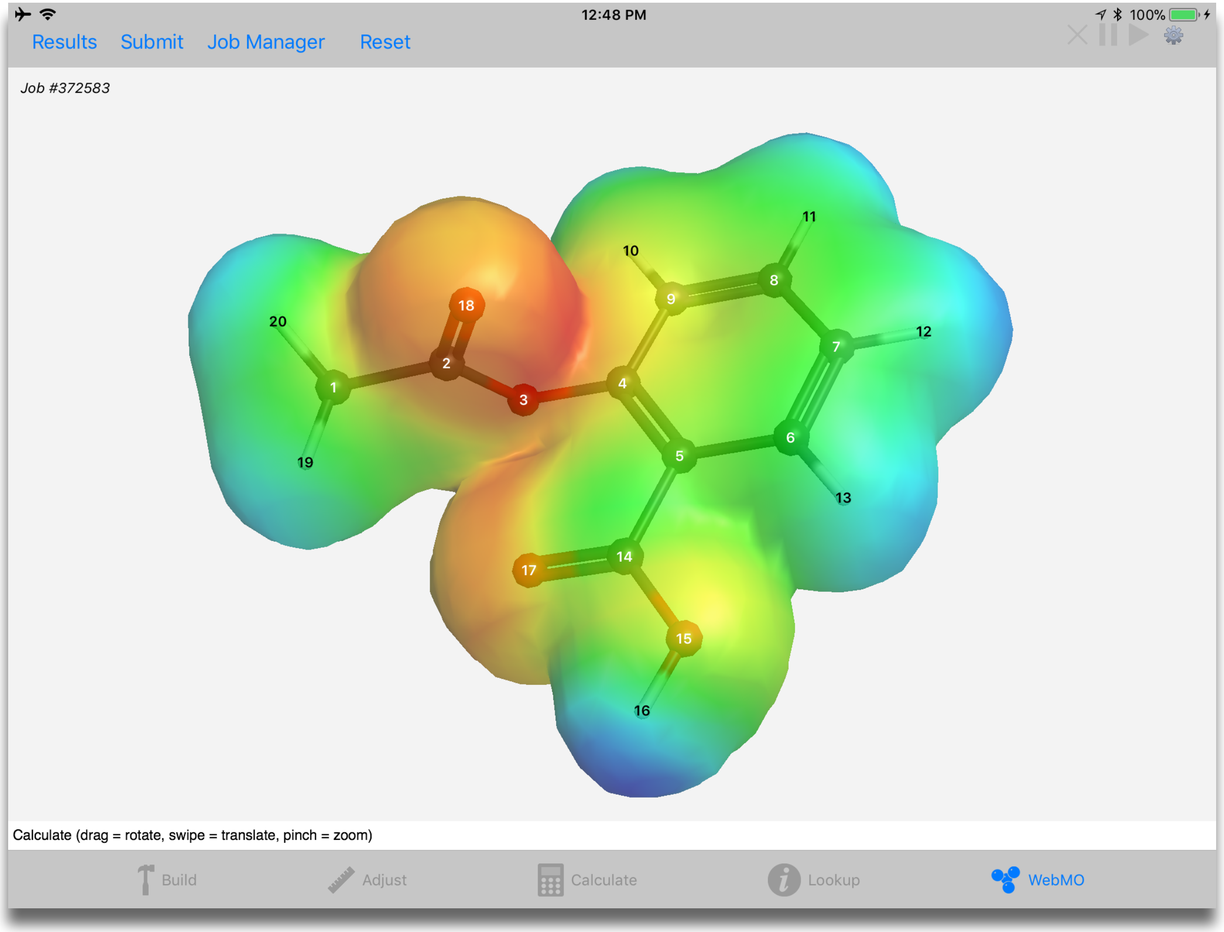

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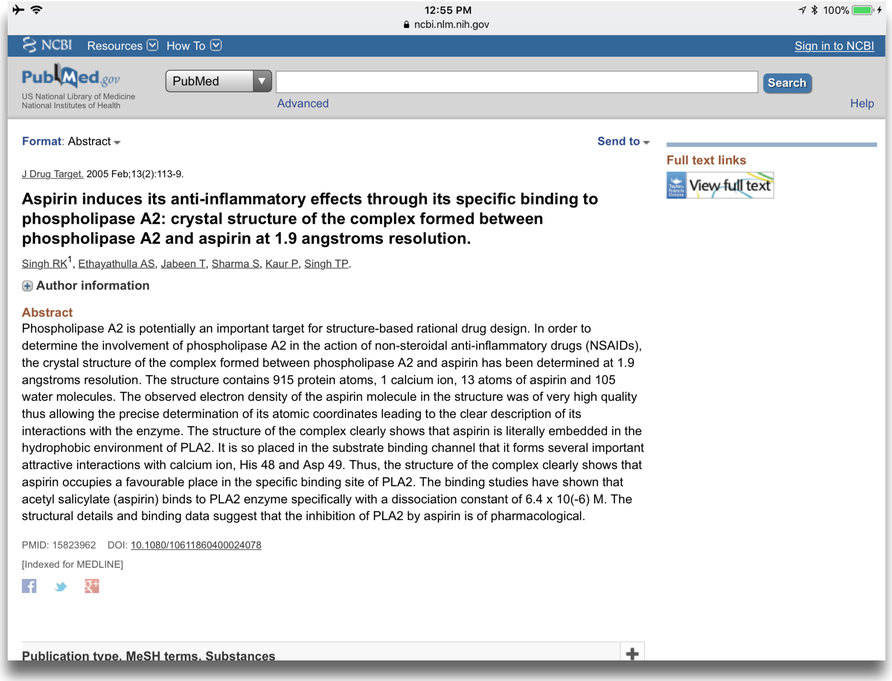
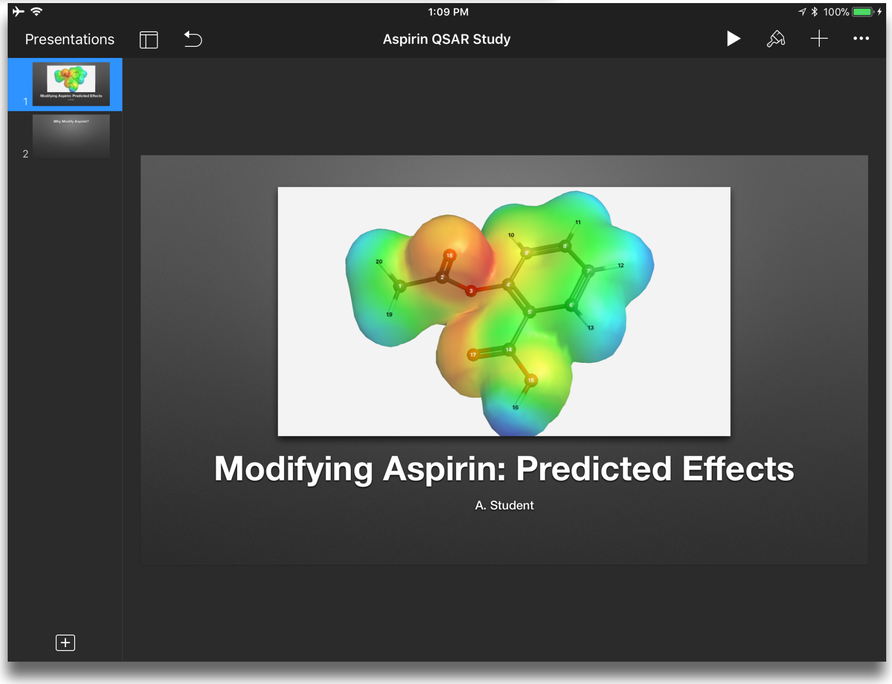




Social	Mobility	Visualization	Storytelling	Gaming
200,000 years	70,000 years	40,000 years	17,000 years	8,000 years

Ruben R. Puentedura, “Technology In Education: The First 200,000 Years” *The NMC Perspective Series: Ideas that Matter*. NMC Summer Conference, 2012.

Social

Bookmarks

RSS Feeds

Discussions

Microblogging

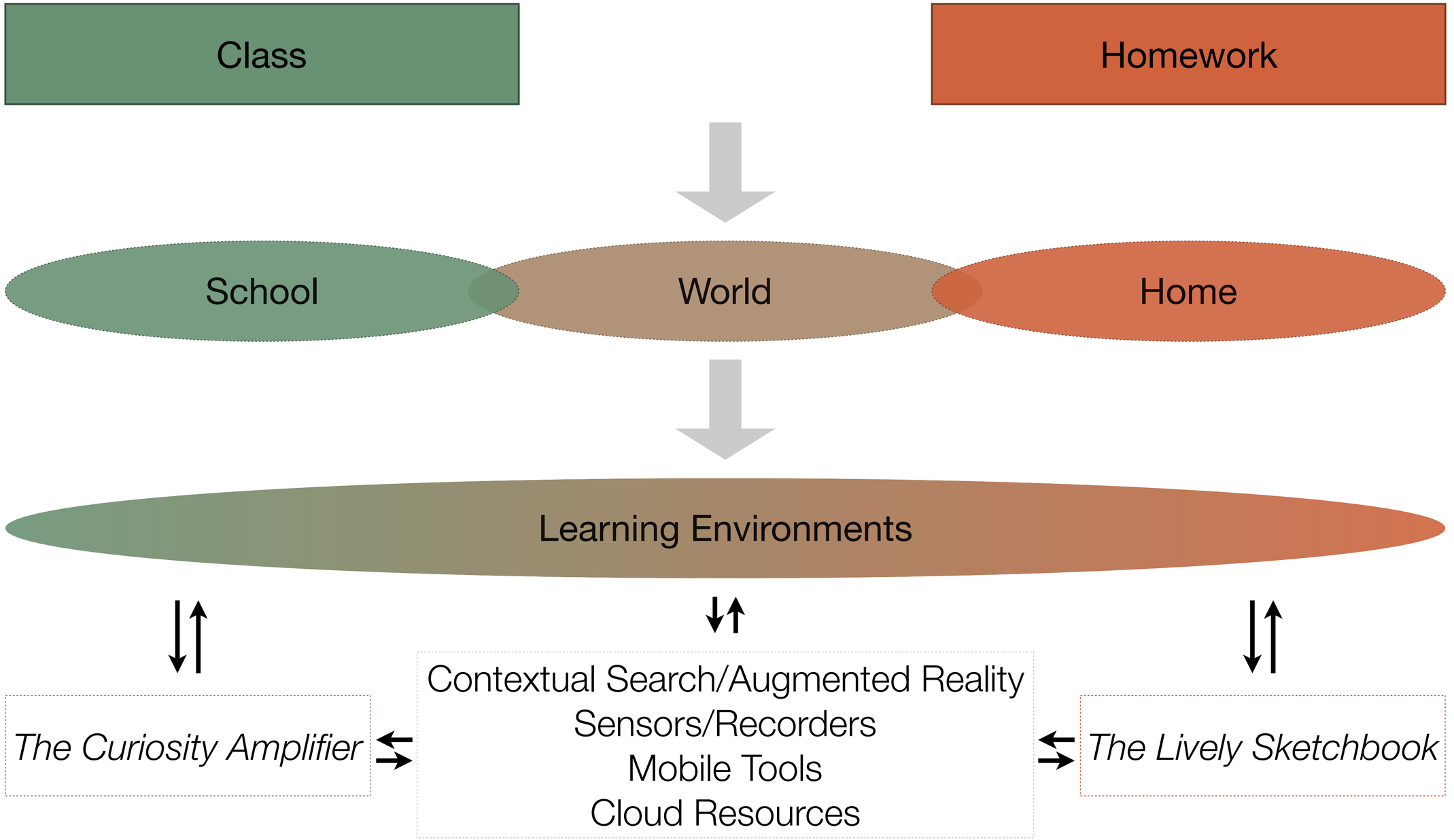
Blogging

Wikis

Telepresence

File Sharing

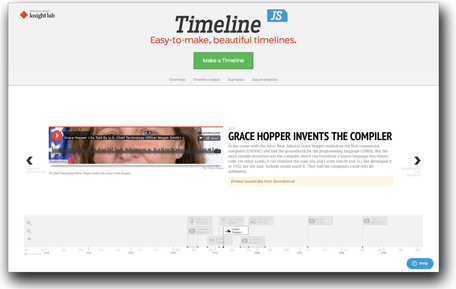
Mobility

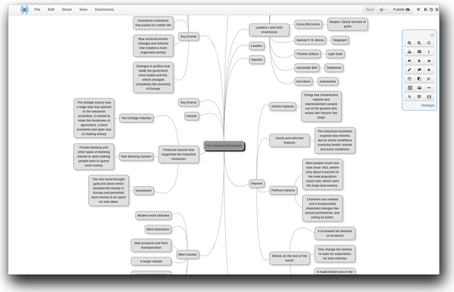


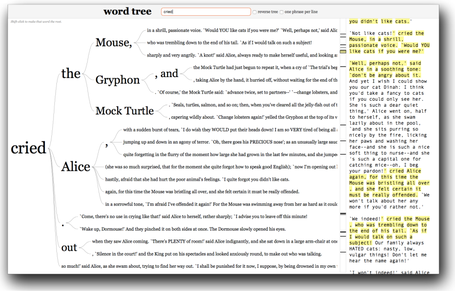
John Seely Brown. “A New Culture of Learning”. *NMC Summer Conference, Closing Keynote*. (2010)

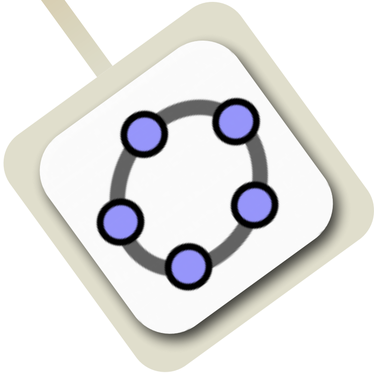
Ruben R. Puentedura, “The Lively Sketchbook”. *Hippasus Blog*. (2010)

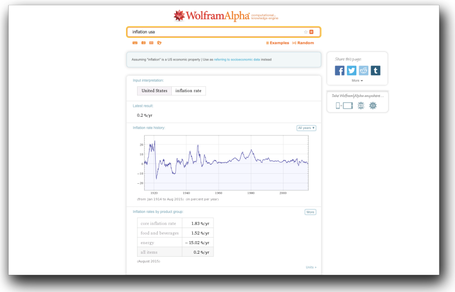
Visualization











Storytelling

Narrative sources;
Narrative constraints

Pictorial vocabulary;
Narrative transitions;
Text/image integration

CDS Seven Elements;
Montage structures

Narrative structures;
Narrative flows

Ludic elements

Image Assembly → Sequential Art → Moving Image → Interactive Media → Interactive Fiction

TIME

PLACE

Infinite Canvas

CONNECTION

SOCIAL

Formal Definition of **Game** (Salen & Zimmerman)

"A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome."

Katie Salen and Eric Zimmerman. *Rules of Play: Game Design Fundamentals*. The MIT Press, 2003.

The EdTech Quintet – Associated Practices	
Social	Communication, Collaboration, Sharing
Mobility	Anytime, Anyplace Learning and Creation
Visualization	Making Abstract Concepts Tangible
Storytelling	Knowledge Integration and Transmission
Gaming	Feedback Loops and Formative Assessment

Social

Mobility

Localization

Visualization

AI + XR

Analysis

Social

Storytelling

Communication

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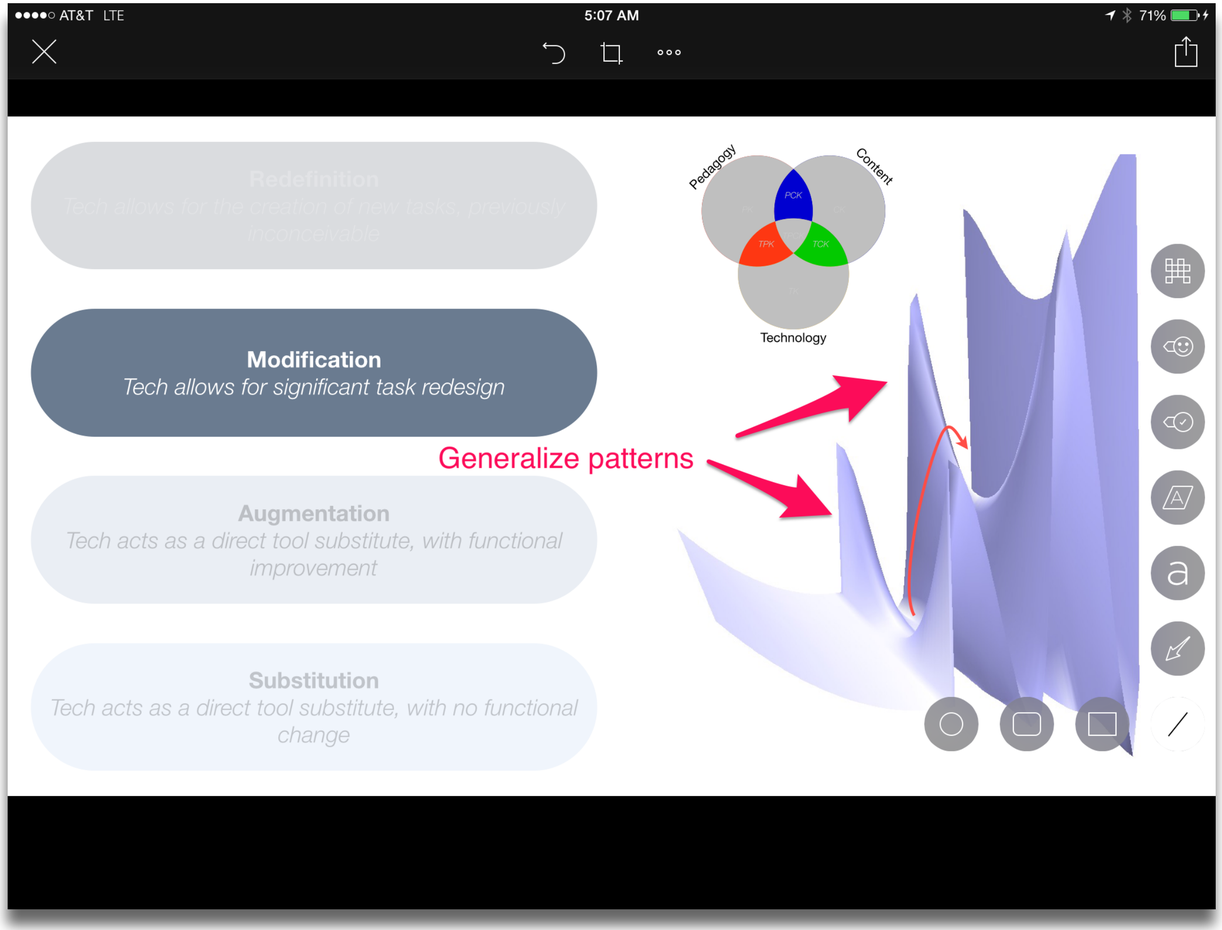

Kenneth A. Kiewra, “Students’ Note-Taking Behaviors and the Efficacy of Providing Instructor’s Notes for Review”. *Contemporary Educational Psychology,* v10 n4. (1985)

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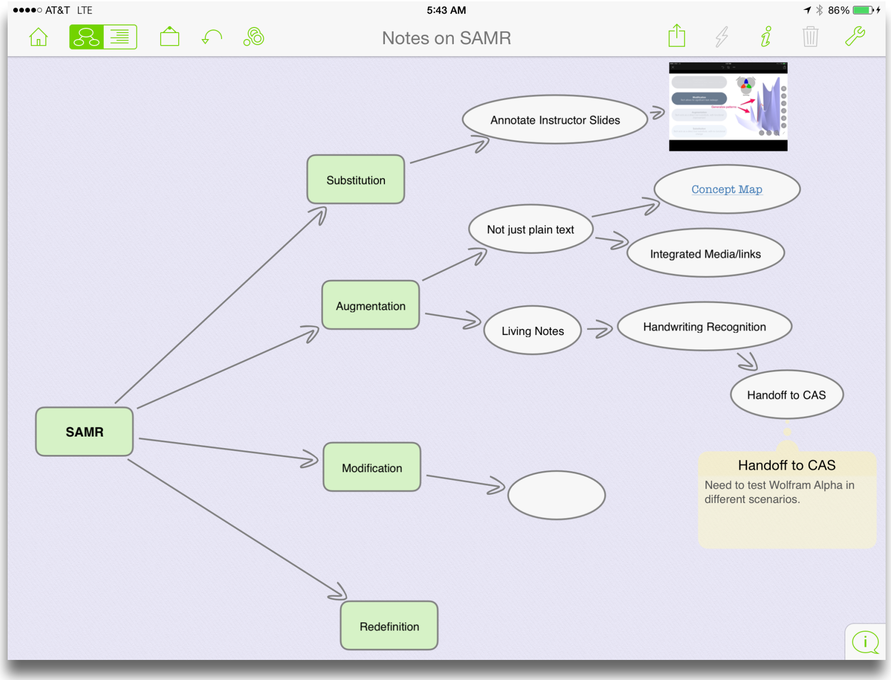

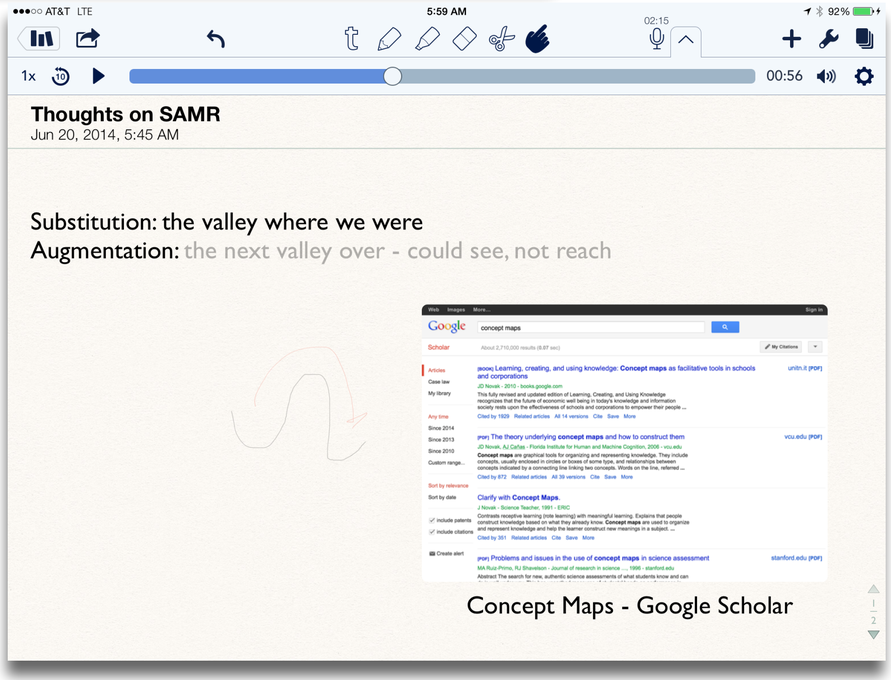

John C. Nesbit and Olusola O. Adesope, "Learning With Concept and Knowledge Maps: A Meta-Analysis". *Review of Educational Research,* Vol. 76, No. 3. (2006)

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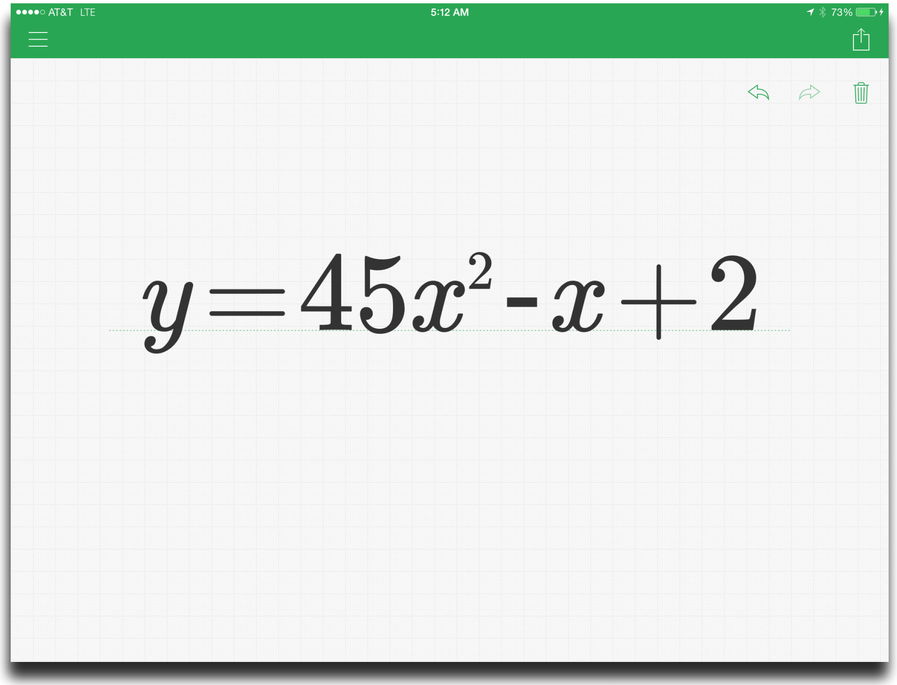

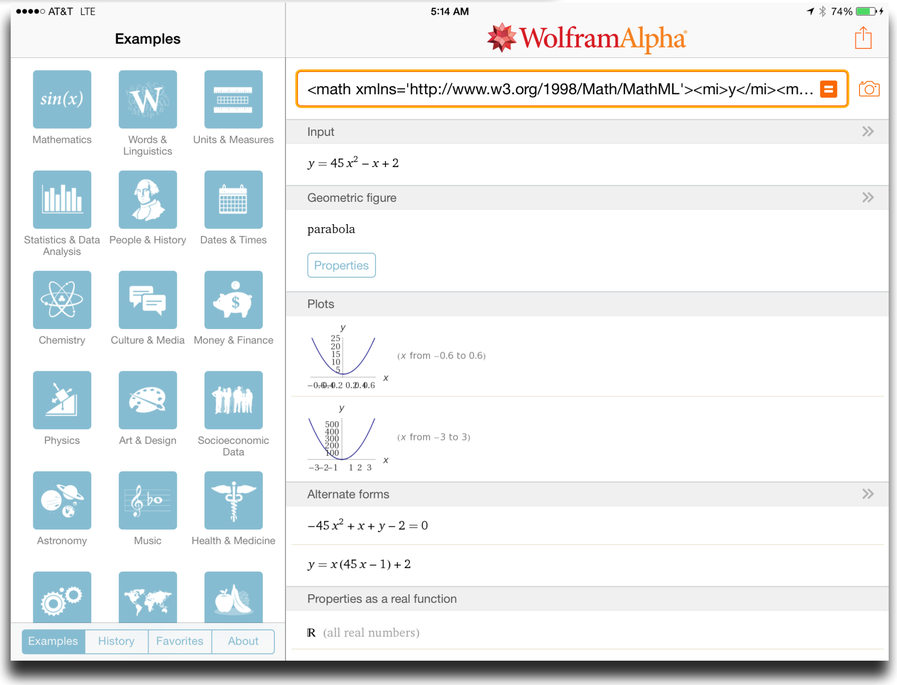

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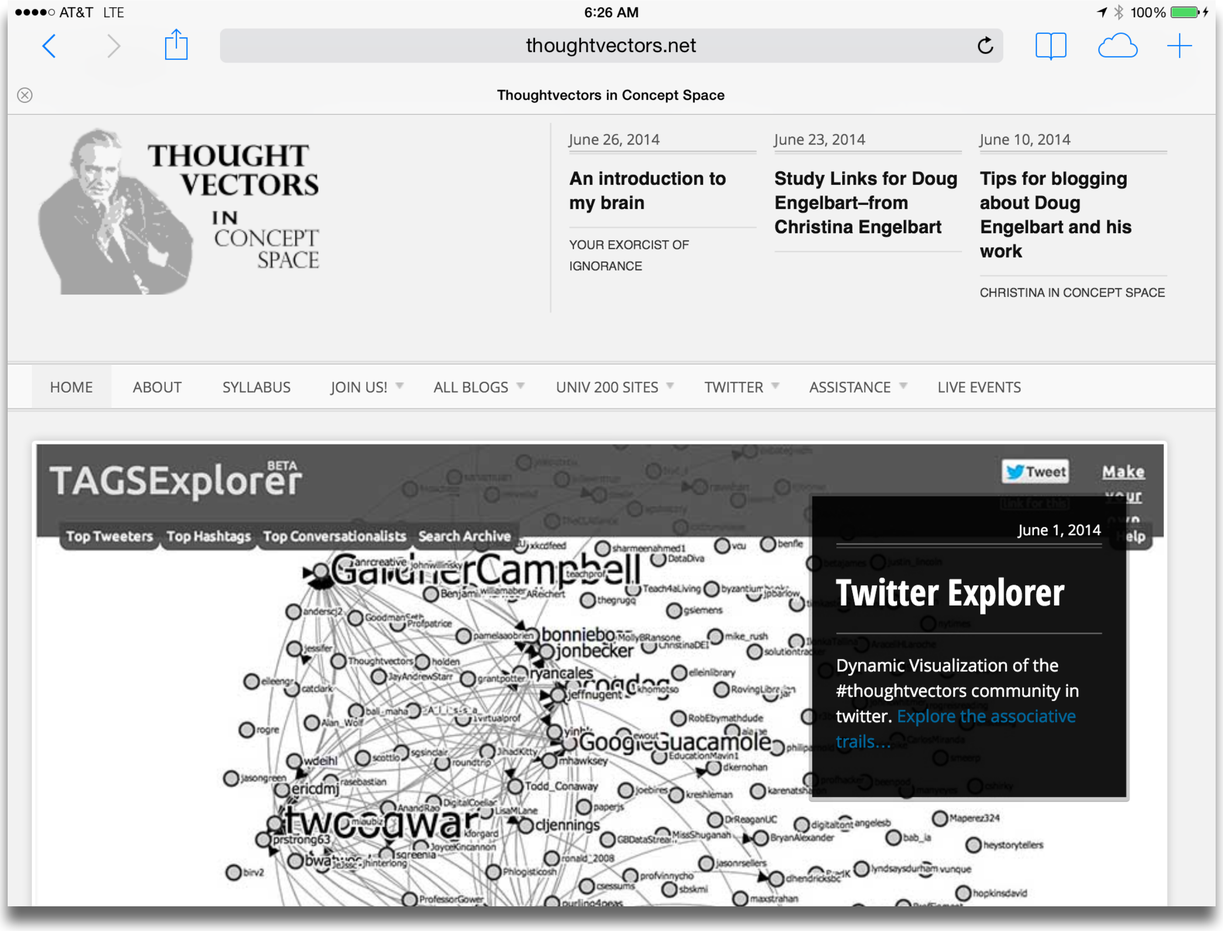


Context I

Dimensions of Computational Thinking

Computational Concepts	Computational Practices	Computational Perspectives
Sequences	Being Incremental and Iterative	Expressing
Loops	Testing and Debugging	Connecting
Events	Reusing and Remixing	Questioning
Parallelism	Abstracting and Modularizing	
Conditionals		
Operators		
Data		

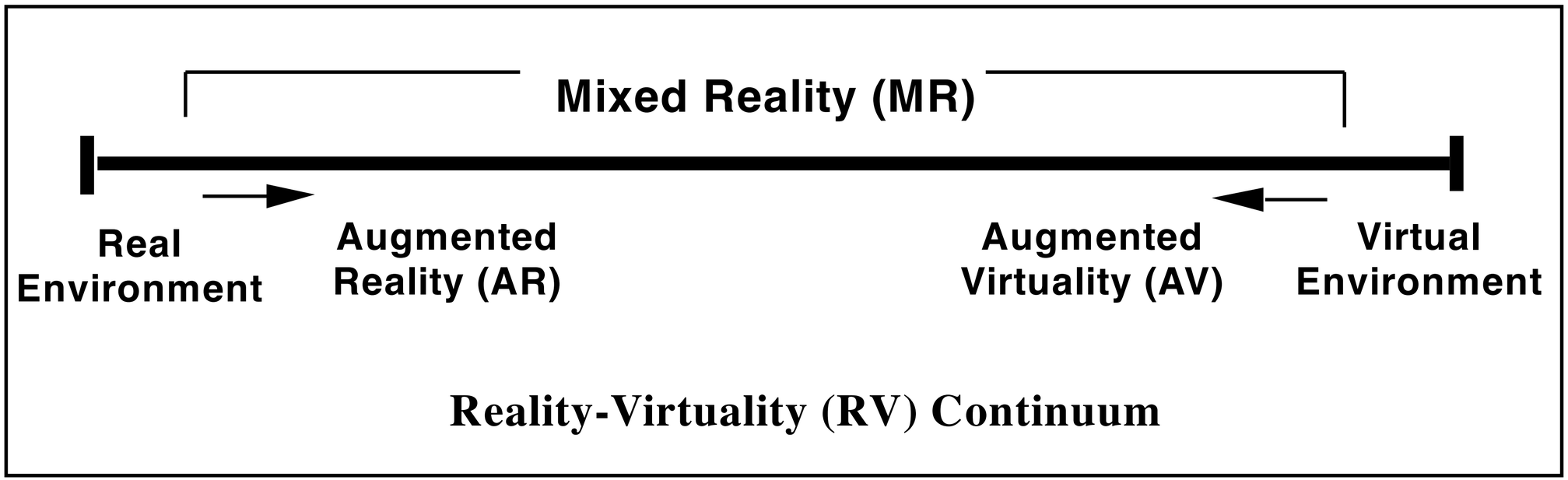
Brennan, Karen, and Mitchel Resnick. "New frameworks for studying and assessing the development of computational thinking." *Proceedings of the 2012 annual meeting of the American Educational Research Association, Vancouver, Canada*. 2012.

Computational Thinking in Math and Science

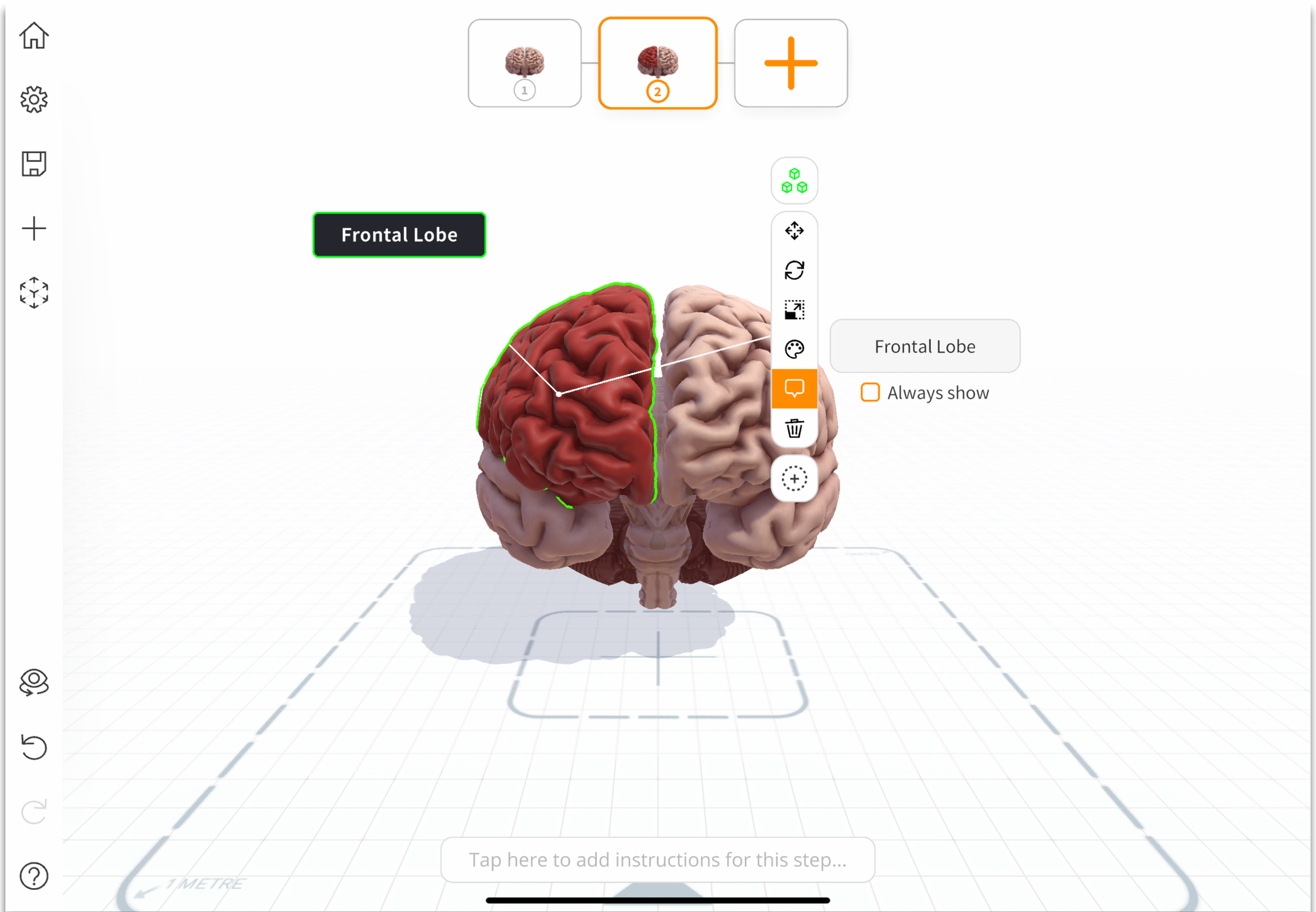
Data Practices	Modeling & Simulation Practices	Computational Problem Solving Practices	System Thinking Practices
Collecting Data	Using Computational Models to Understand a Concept	Preparing Problems for Computational Solutions	Investigating a Complex System as a Whole
Creating Data	Using Computational Models to Find and Test Solutions	Programming	Understanding the Relationships within a System
Manipulating Data	Assessing Computational Models	Choosing Effective Computational Tools	Thinking in Levels
Analyzing Data	Designing Computational Models	Assessing Different Approaches/ Solutions to a Problem	Communicating Information about a System
Visualizing Data	Constructing Computational Models	Developing Modular Computational Solutions	Defining Systems and Managing Complexity
		Creating Computational Abstractions	
		Troubleshooting and Debugging	

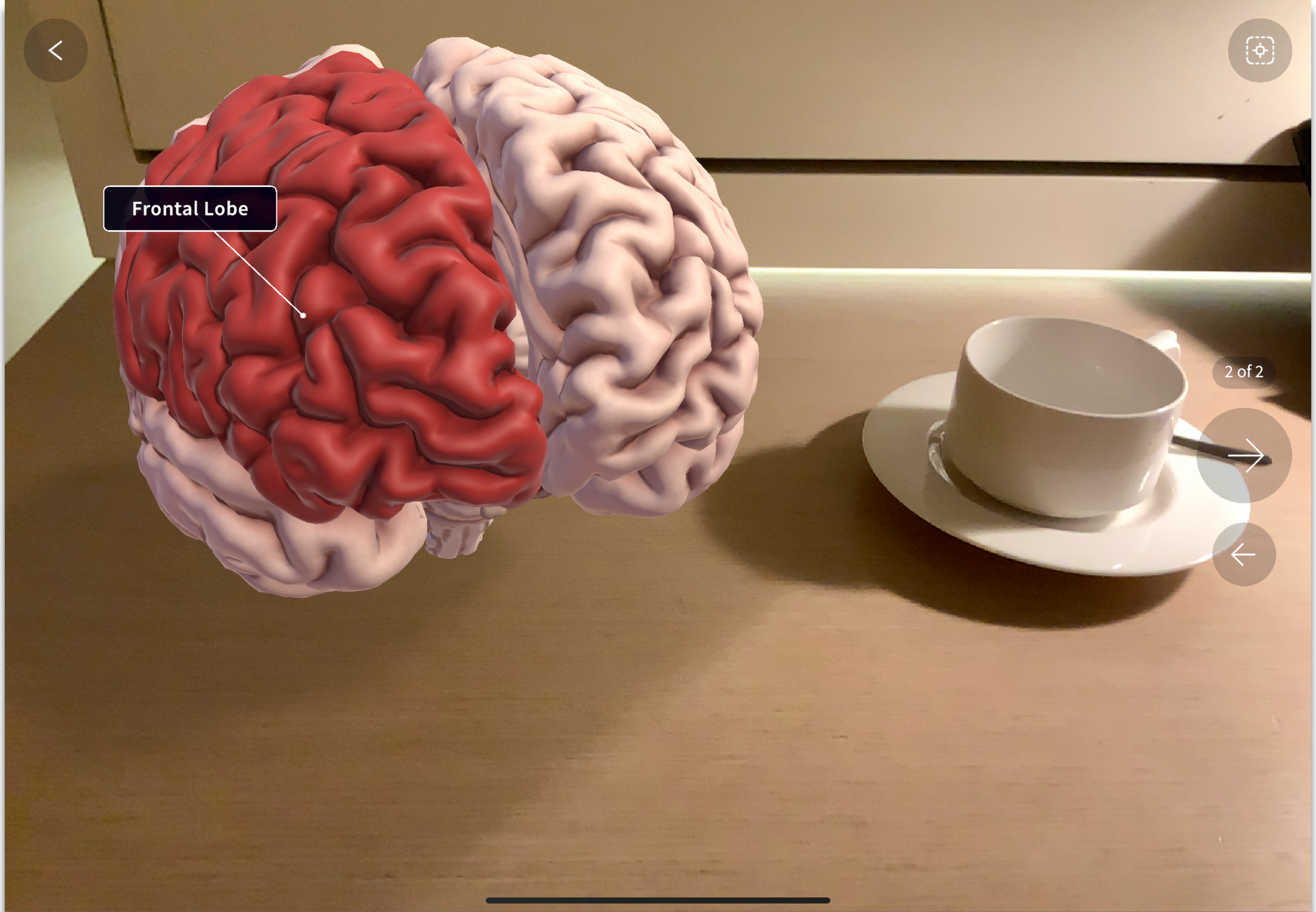
Weintrop, David, et al. "Defining computational thinking for mathematics and science classrooms." *Journal of Science Education and Technology* 25.1 (2016): 127-147.

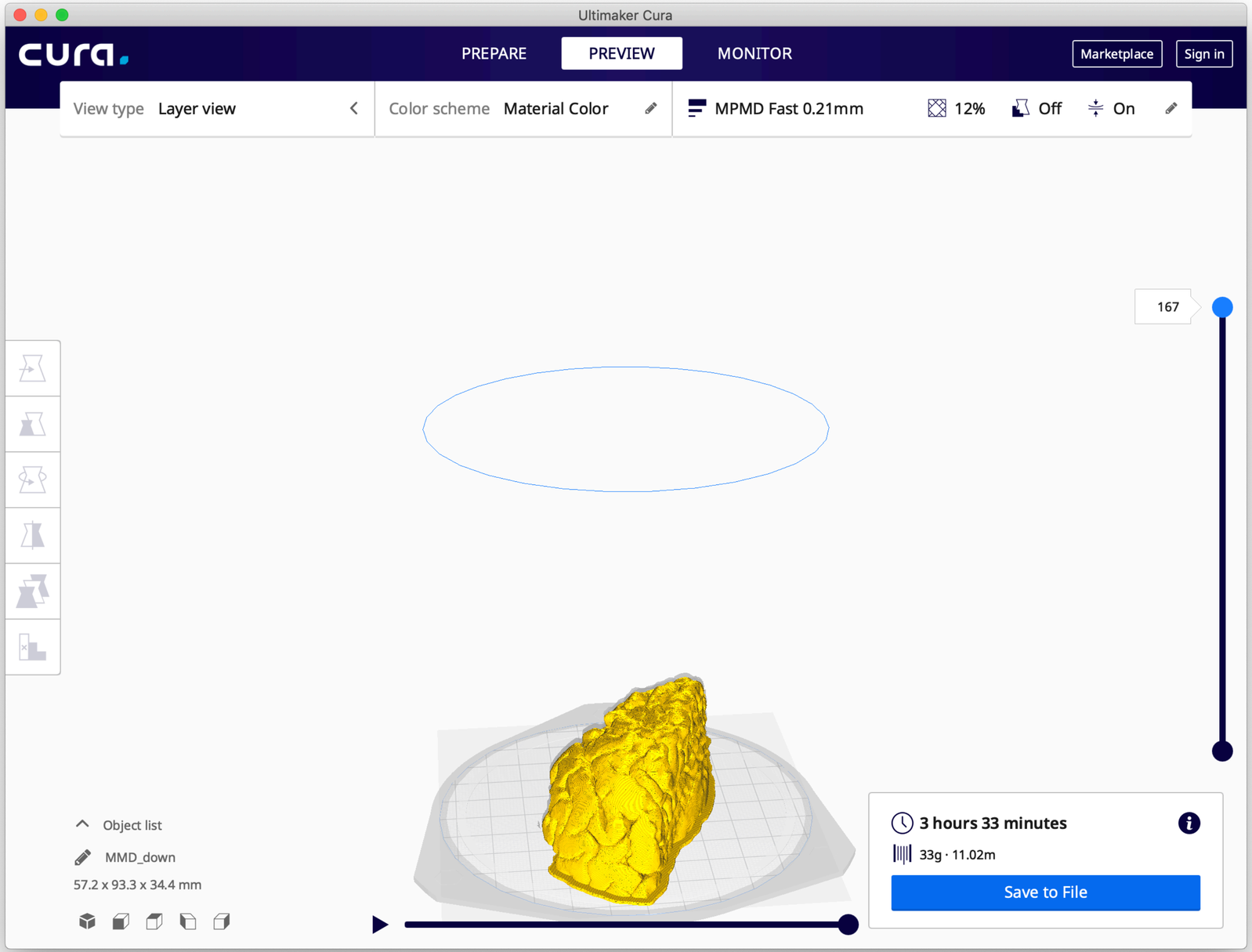
Defining XR



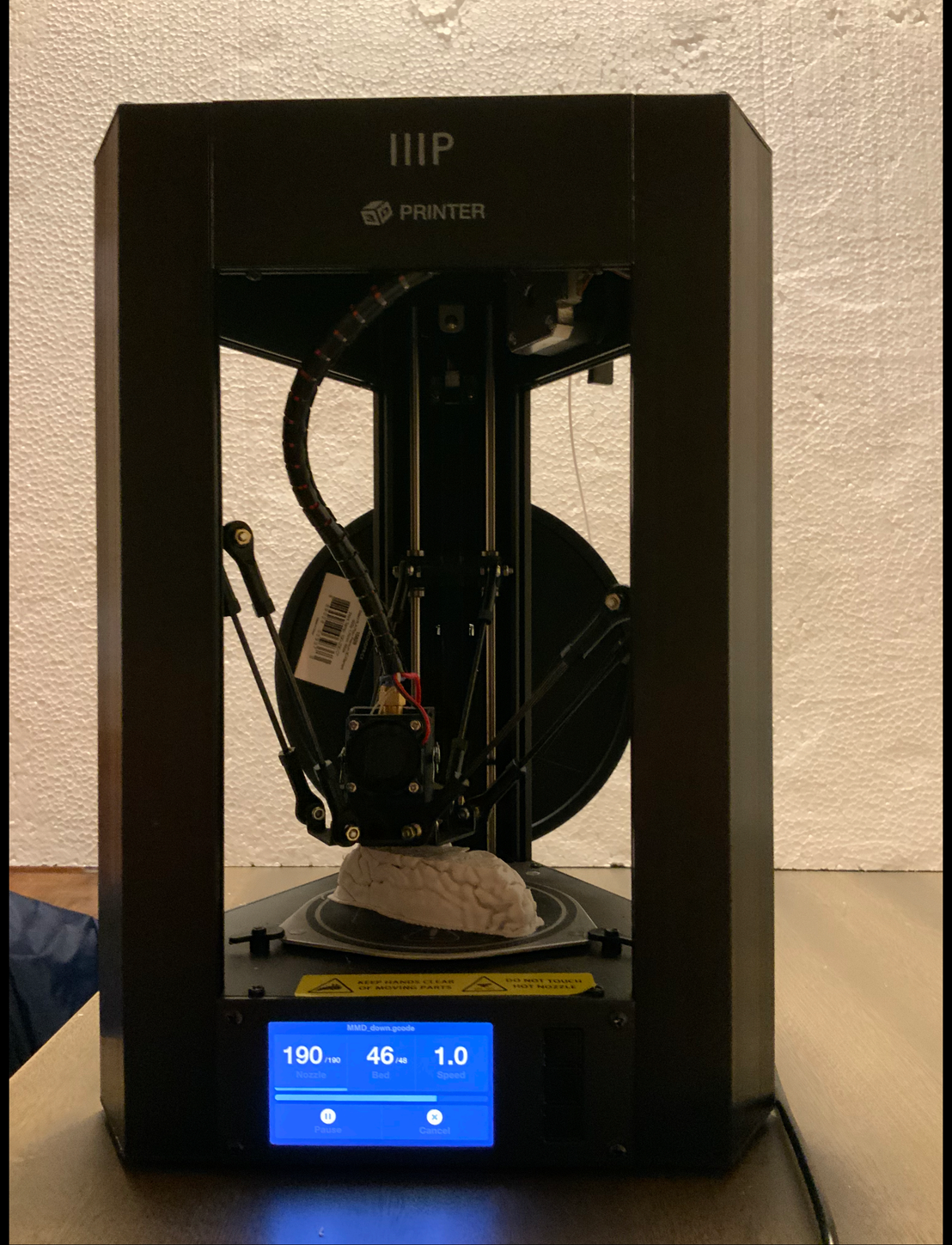
Milgram, Paul, et al. "Augmented reality: A class of displays on the reality-virtuality continuum." *Telemanipulator and telepresence technologies*. Vol. 2351. International Society for Optics and Photonics. (1994)


1
2
Frontal Lobe
Frontal Lobe
Always show
Tap here to add instructions for this step...
1 METRE

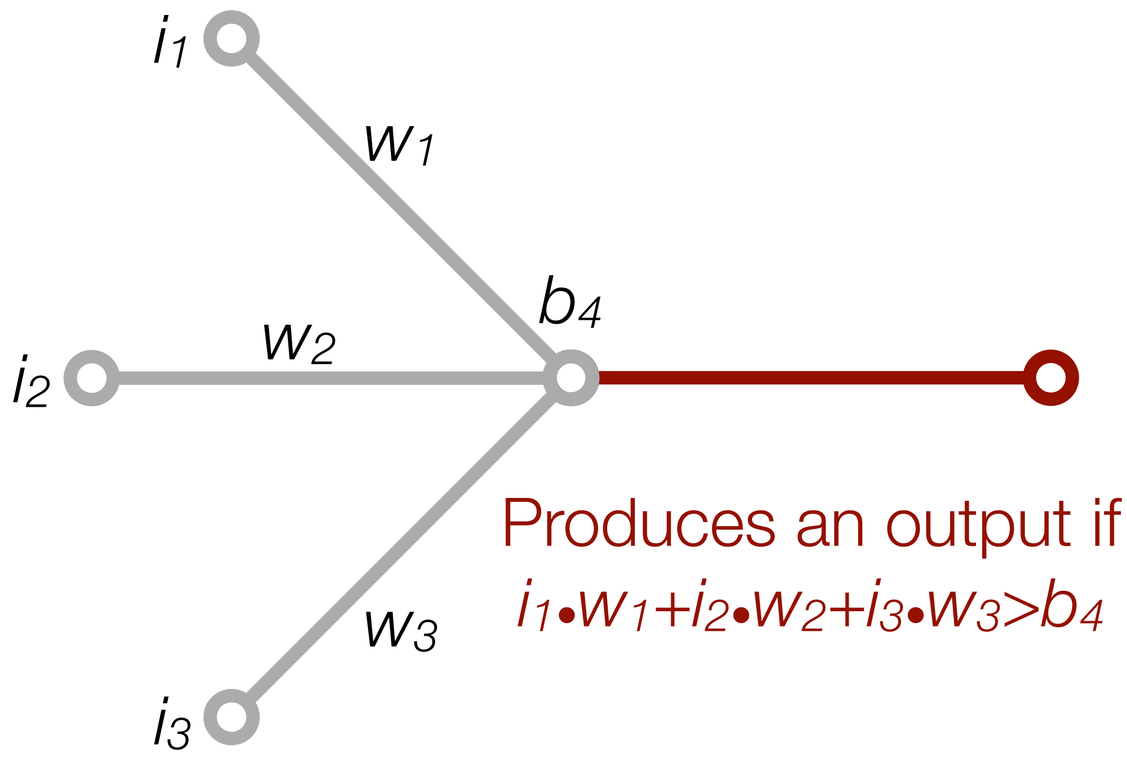

Frontal Lobe
2 of 2



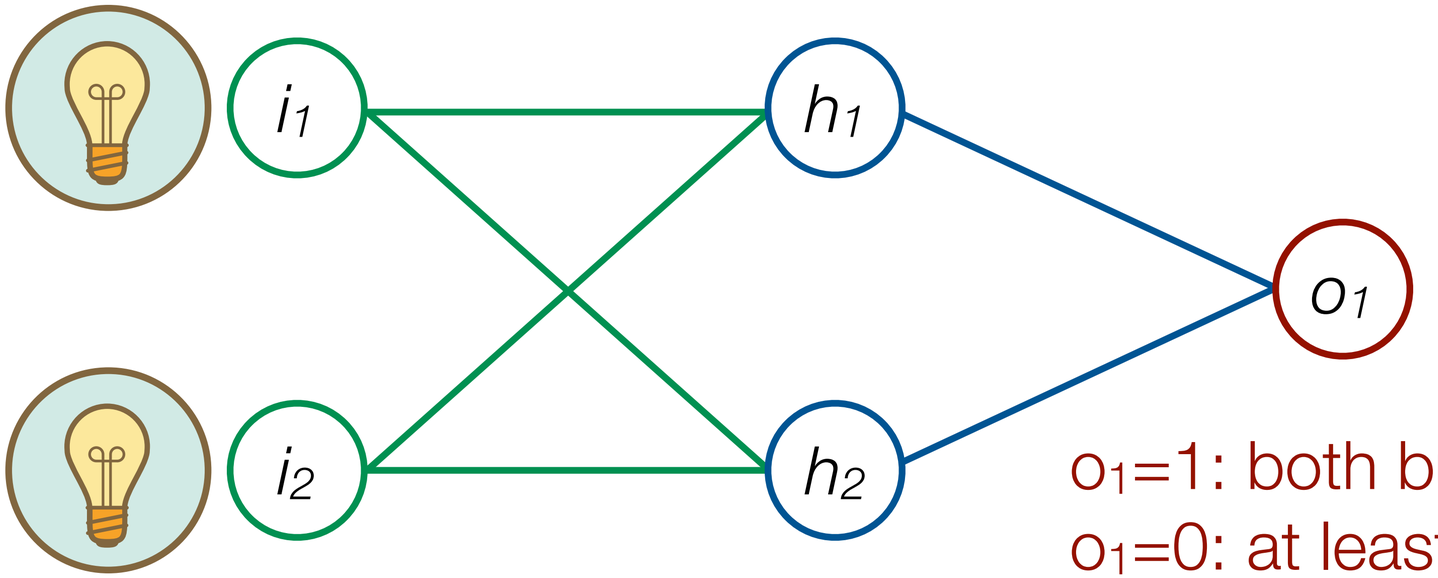
Original model by Medhat Megahed, available online at: https://www.thingiverse.com/thing:2591902


IIIP
PRINTER
KEEP HANDS CLEAR OF MOVING PARTS
DO NOT TOUCH HOT NOZZLE
MMD_down.gcode
190 /190
Nozzle
46 /48
Bed
1.0
Speed
Pause
Cancel

Simple McCulloch–Pitts/Perceptron Model



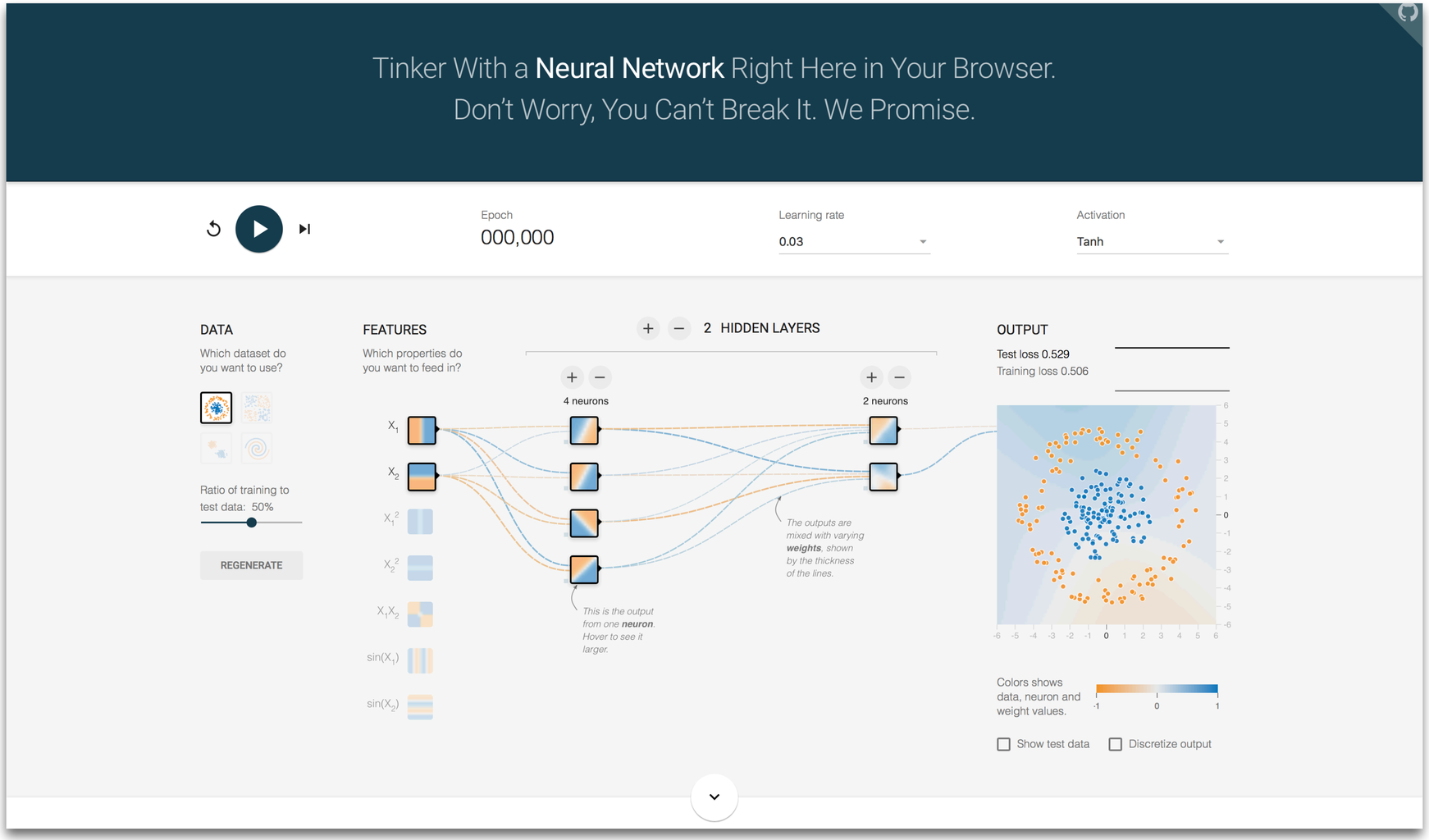
A Simple Example: A Light Bulb Tester



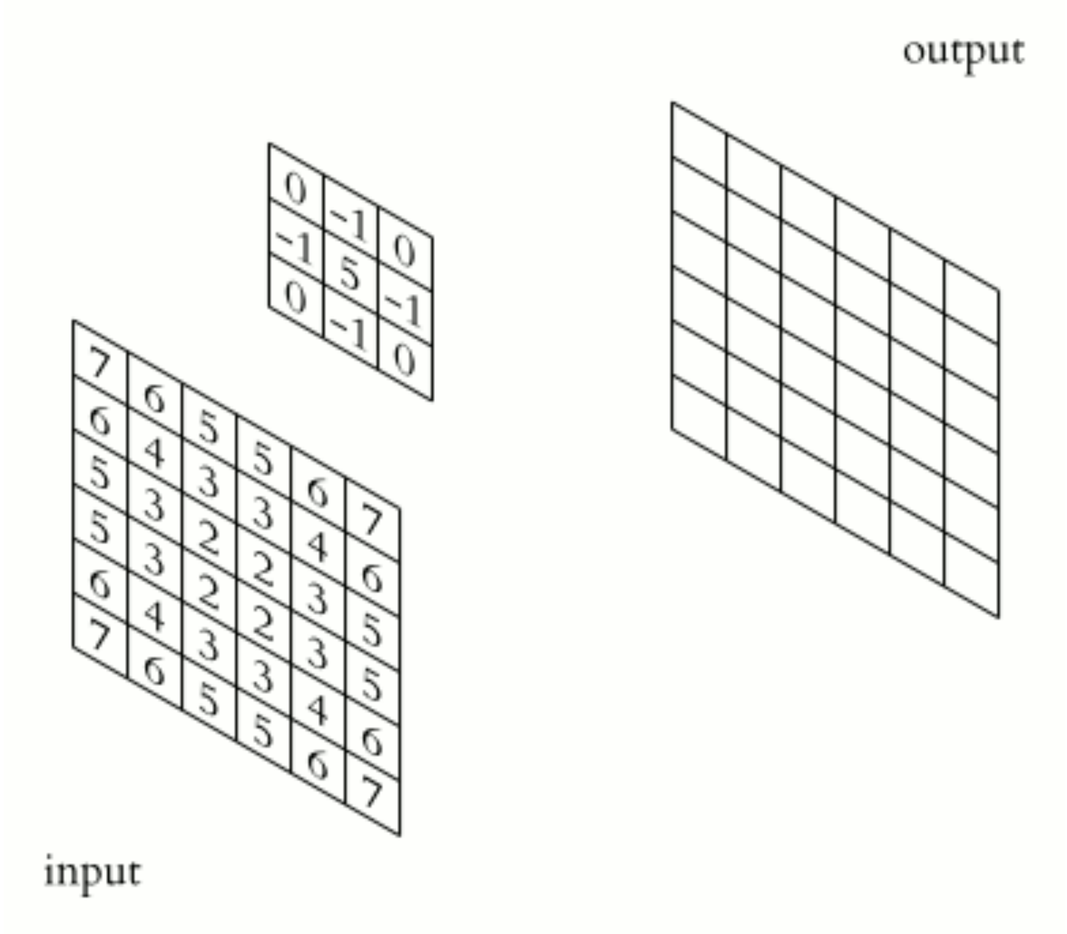
o_1=1: both bulbs working

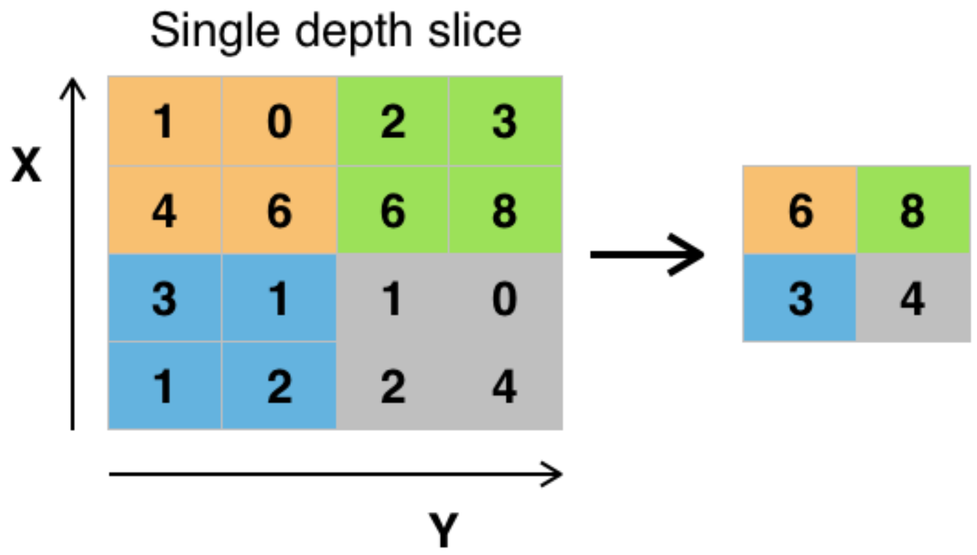
o_1=0: at least one bulb not working

A Neural Network Playground: http://tinyurl.com/mlti17nndemo



Convolution and Pooling Layers





Images Source: Wikipedia

AI in Medical Education -Basic Exercises

- Bots
- Recommendation Systems
- Regression and Clustering
- Image Classification
- Object Detection
- Sequence Classification

Turi Create

Check out our talks at WWDC 2019 and at WWDC 2018!

Turi Create simplifies the development of custom machine learning models. You don't have to be a machine learning expert to add recommendations, object detection, image classification, image similarity or activity classification to your app.

- **Easy-to-use:** Focus on tasks instead of algorithms
- **Visual:** Built-in, streaming visualizations to explore your data
- **Flexible:** Supports text, images, audio, video and sensor data
- **Fast and Scalable:** Work with large datasets on a single machine
- **Ready To Deploy:** Export models to Core ML for use in iOS, macOS, watchOS, and tvOS apps

With Turi Create, you can accomplish many common ML tasks:

ML Task	Description
Recommender	Personalize choices for users
Image Classification	Label images
Drawing Classification	Recognize Pencil/Touch Drawings and Gestures
Sound Classification	Classify sounds
Object Detection	Recognize objects within images
One Shot Object Detection	Recognize 2D objects within images using a single example
Style Transfer	Stylize images
Activity Classification	Detect an activity using sensors
Image Similarity	Find similar images
Classifiers	Predict a label
Regression	Predict numeric values
Clustering	Group similar datapoints together
Text Classifier	Analyze sentiment of messages

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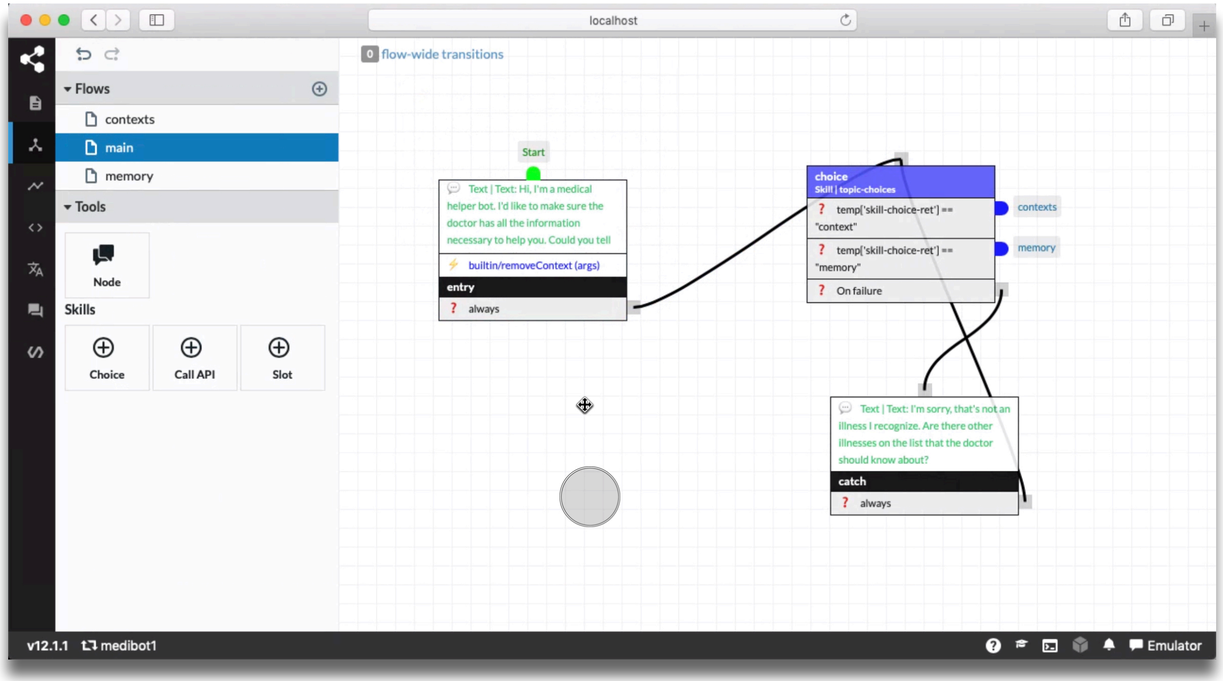

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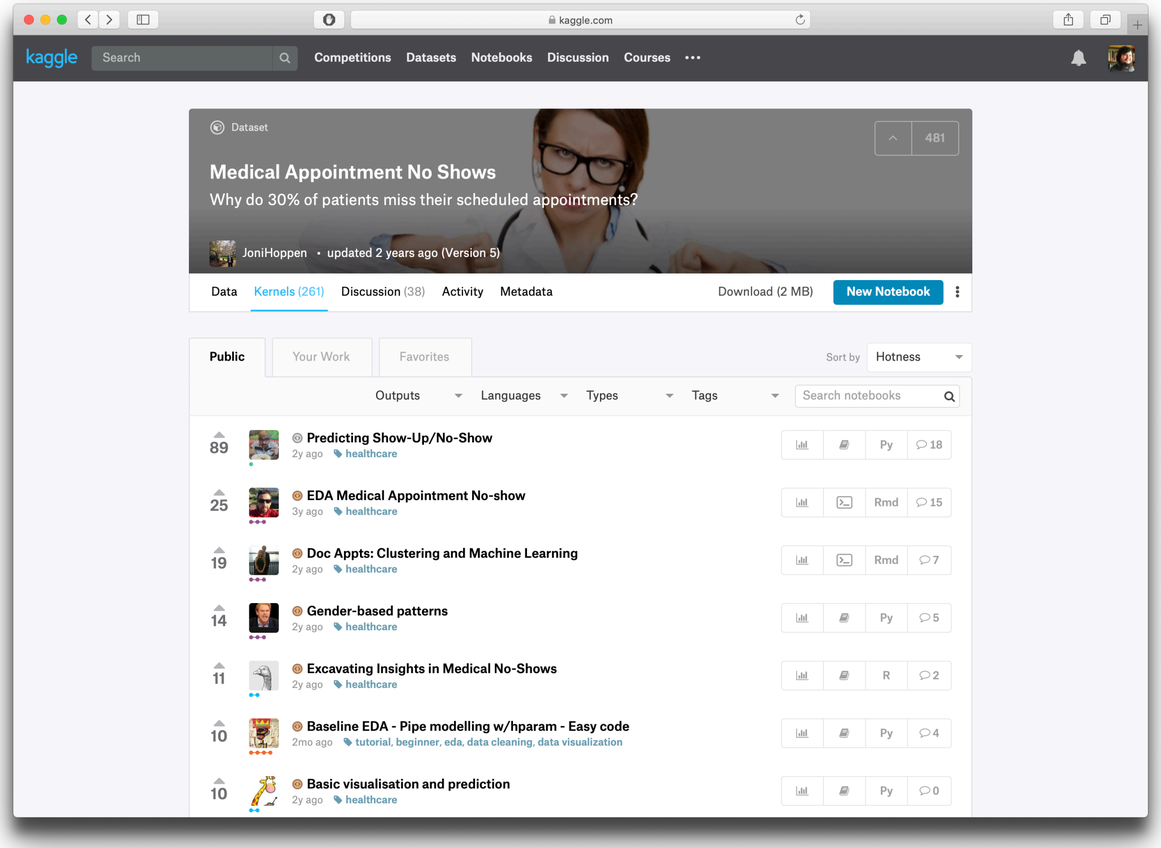

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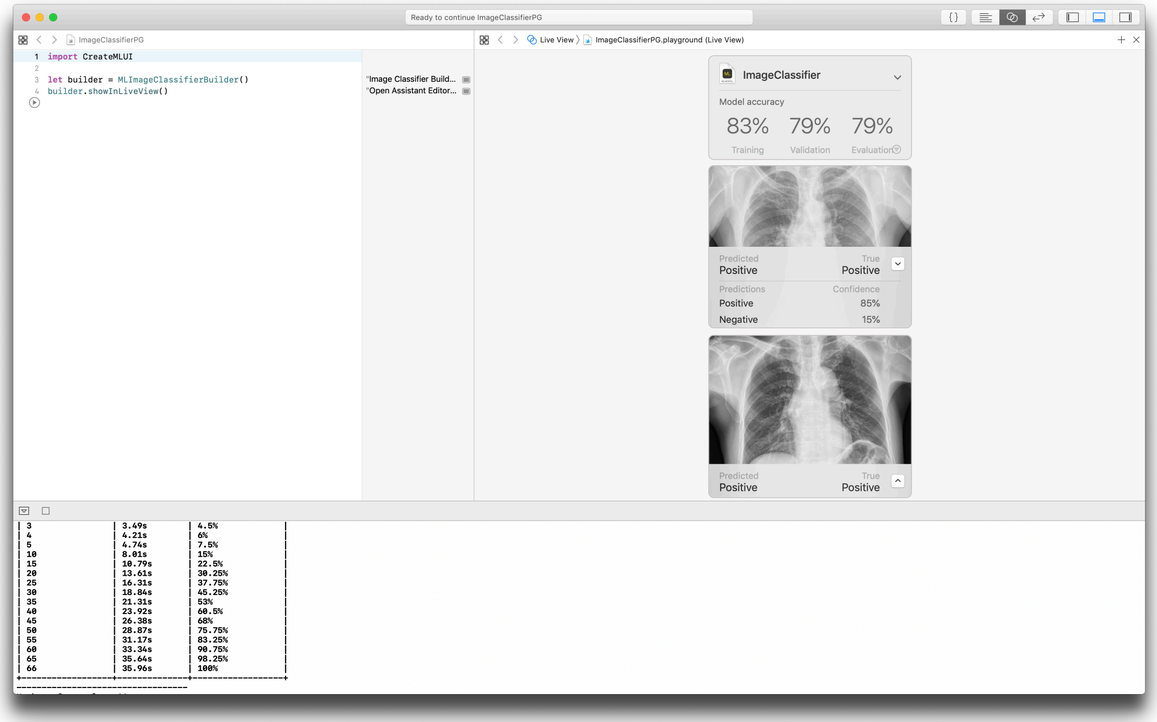


Augmentation

Tech acts as a direct tool substitute, with functional improvement

Substitution

Tech acts as a direct tool substitute, with no functional change

Redefinition

Tech allows for the creation of new tasks, previously inconceivable

Modification

Tech allows for significant task redesign

Augmentation

Tech acts as a direct tool substitute, with functional improvement

Substitution

Tech acts as a direct tool substitute, with no functional change

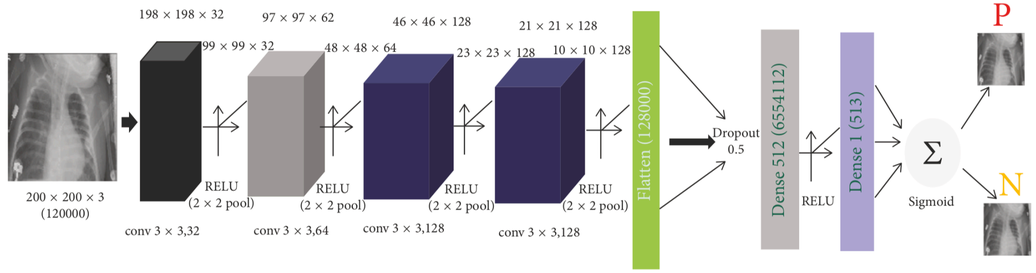


FIGURE 3: The proposed architecture.

TABLE 2: The output of the proposed network architecture.

Layer (type)	Output shape	Turtles
conv2d_9 (conv2D)	(None, 198, 198, 32)	896
max_Pooling2d_9 (MaxPooling2)	(None, 99, 99, 32)	0
conv2d_10 (conv2D)	(None, 97, 97, 64)	18496
max_Pooling2d_10 (MaxPooling2)	(None, 48, 48, 64)	0
conv2d_11 (conv2D)	(None, 46, 46, 128)	73856
max_Pooling2d_11 (MaxPooling2)	(None, 23, 23, 128)	0
conv2d_12 (conv2D)	(None, 21, 21, 128)	147584
max_Pooling2d_12 (MaxPooling2)	(None, 10, 10, 128)	0
flatten_3 (Flatten)	(None, 12800)	0
dropout_3 (Dropout)	(None, 12800)	0
dense_5 (Dense)	(None, 512)	6554112
dense_6 (Dense)	(None, 1)	513

Stephen, Okeke, et al. "An Efficient Deep Learning Approach to Pneumonia Classification in Healthcare." *Journal of healthcare engineering* (2019).

Choosing the First SAMR Ladder Project: Three Options

- **Your Passion:**
  - If you had to pick one topic from your class that best exemplifies why you became fascinated with this aspect of medicine, what would it be?
- **Barriers to Your Students' Progress:**
  - Is there a topic in your class that a significant number of students get stuck on, and fail to progress beyond?
- **What Students Will Do In the Future:**
  - Which topic from your class would, if deeply understood, best serve the interests of your students as future physicians?

In this exercise you will design a SAMR ladder to transform a unit of instruction; the complete exercise should take about 1 hour.

- Please break up into teams of 3-5 participants.
- Your team should take 10 minutes to select the topic that you will use as the basis for your ladder. You should select the topic according to one of these criteria:
    - Your Passion:
      If you had to pick one topic from your class that best exemplifies why you became fascinated with this aspect of medicine, what would it be?
    - Barriers to Your Students' Progress:
      Is there a topic in your class that a significant number of students get stuck on, and fail to progress beyond?
    - What Students Will Do In the Future:
      Which topic from your class would, if deeply understood, best serve the interests of your students as future physicians?
- You should make sure that the topic is not too broad or too narrow - for instance, trying to transform the entire Physiology curriculum would be too ambitious for this exercise, but focusing solely on teaching the structure of myosin would be too narrow.
- Having chosen a topic, you should design a SAMR ladder to transform how it is taught today. Plan to spend about 20 minutes identifying key pedagogical goals and creating a "rough" version of the ladder, followed by 20 minutes refining and revising the ladder to put it into final form, including the tools you plan to use and reasonably detailed descriptions of the activities planned.
- In the final 10 minutes of this exercise, transcribe a description of your ladder, making sure that the writeup is understandable by someone who has not participated in your discussions, and is detailed enough that they could implement your ladder with a minimum of additional work needed.

Determining SAMR Level: Questions and Transitions

- **Substitution:**
  - What is gained by replacing the older technology with the new technology?
- **Substitution to Augmentation:**
  - Has an improvement been added to the task process that could not be accomplished with the older technology at a fundamental level?
  - How does this feature contribute to the design?
- **Augmentation to Modification:**
  - How is the original task being modified?
  - Does this modification fundamentally depend upon the new technology?
  - How does this modification contribute to the design?
- **Modification to Redefinition:**
  - What is the new task?
  - Is any portion of the original task retained?
  - How is the new task uniquely made possible by the new technology?
  - How does it contribute to the design?

S to A: The Value of Shared Practices

- Augmented Note Taking and Annotation
- Visualization Methods:
  - 5 Primary Domains: Space, Time, Networks, Text, Number
- Simple Blogging
- Simple Digital Storytelling Video
- Flipped Classroom:
  - Materials Creation
  - Peer Discussion/Instruction Methods
- Simple Interactive Fiction
- LMS Practices

Black and Wiliam: Defining Formative Assessment

"Practice in a classroom is formative to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers, to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have taken in the absence of the evidence that was elicited."

Black, P. and Wiliam D. "Developing the theory of formative assessment." *Educational Assessment, Evaluation and Accountability*. 21:5-31 (2009)

Wiliam: A Framework for Formative Assessment

	Where the learner is going	Where the learner is right now	How to get there
Teacher	1 Clarifying learning intentions and criteria for success	2 Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding	3 Providing feedback that moves learners forward
Peer	Understanding and sharing learning intentions and criteria for success	4 Activating students as instructional resources for one another	
Learner	Understanding learning intentions and criteria for success	5 Activating students as the owners of their own learning	

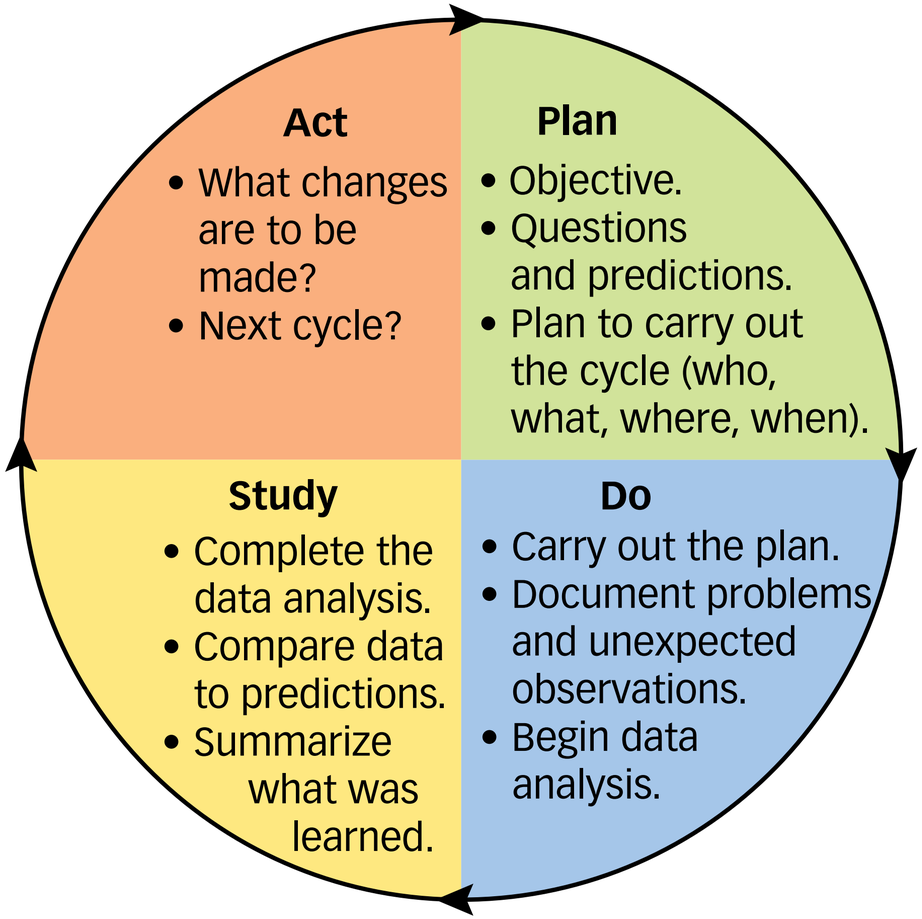
Dylan Wiliam, *Embedded Formative Assessment*. Solution Tree (2011)

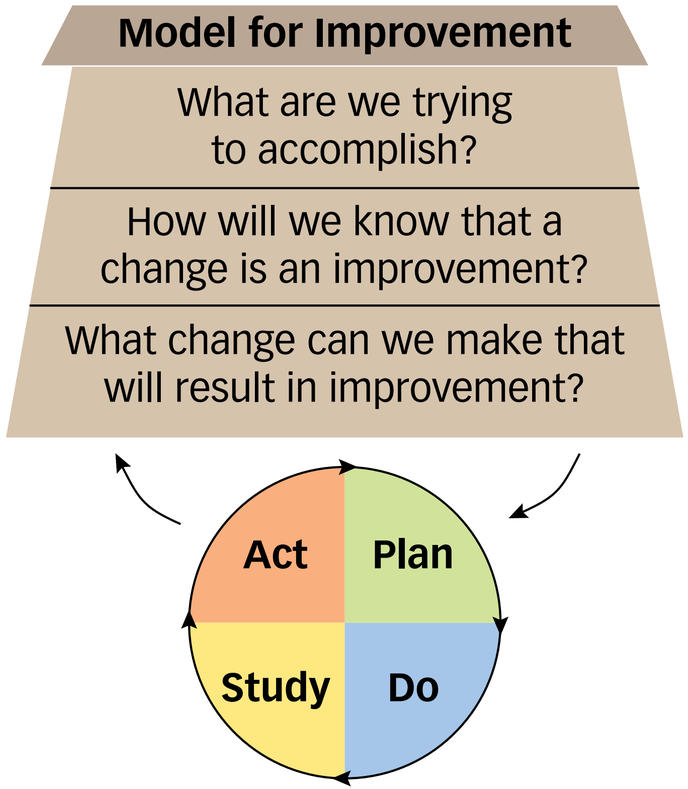
Context II

Redefinition *Tech allows for the creation of new tasks, previously inconceivable*	**Extended Thinking**
Modification *Tech allows for significant task redesign*	**Strategic Thinking**
Augmentation *Tech acts as a direct tool substitute, with functional improvement*	**Skills and Concepts**
Substitution *Tech acts as a direct tool substitute, with no functional change*	**Recall and Reproduction**

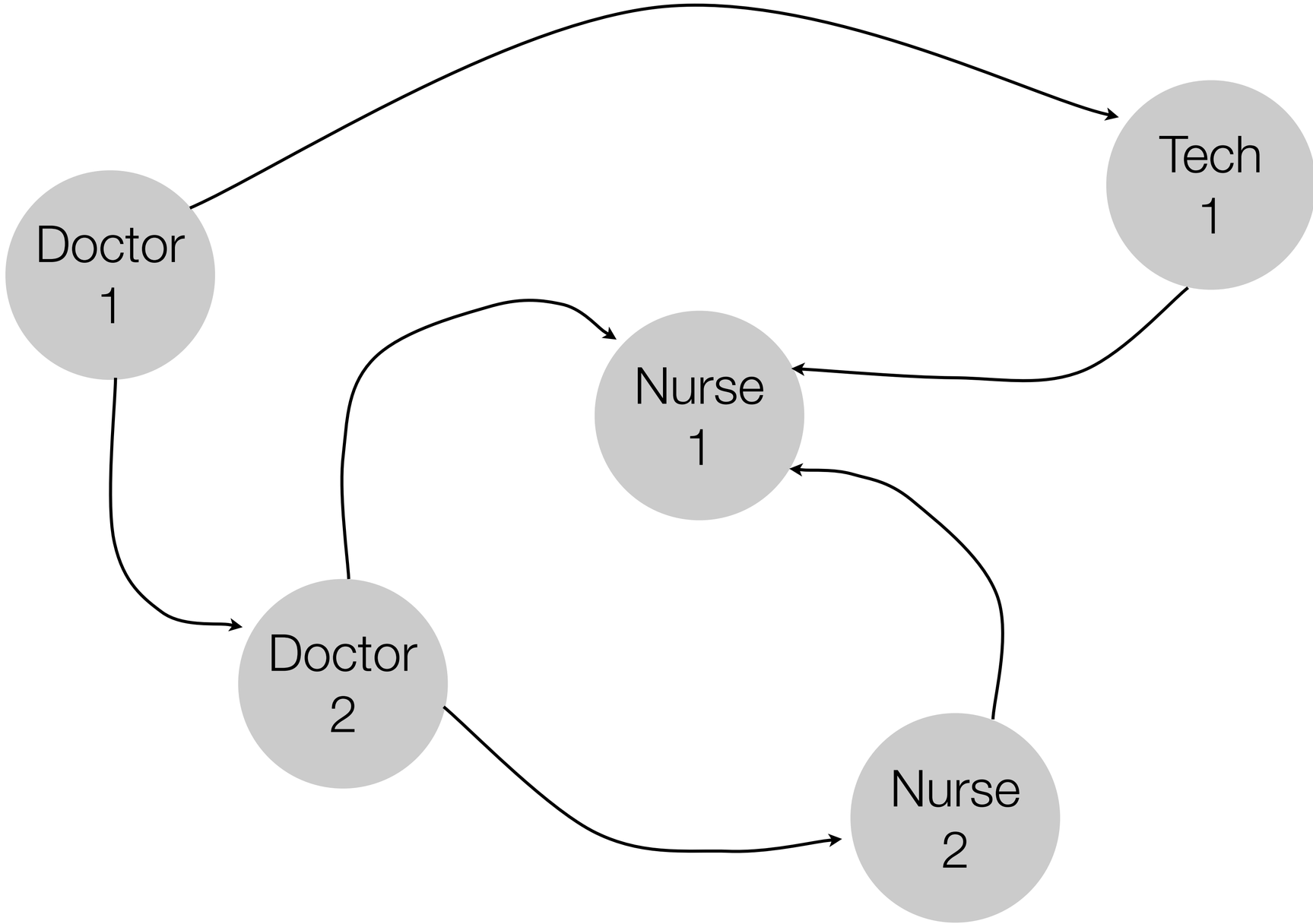
Webb, Norman L. *Depth-of-knowledge levels for four content areas*. (2002)

Deming's PDSA Cycle

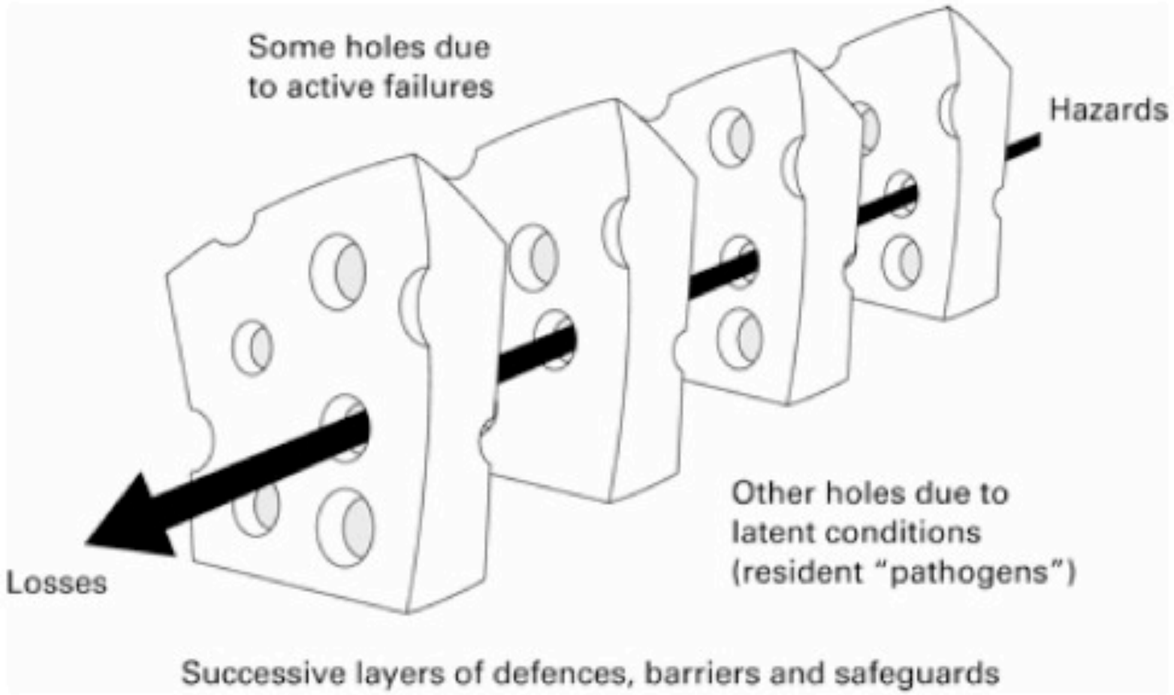




Ronald D. Moen and Clifford L. Norman. *Circling Back: Clearing up myths about the Deming cycle and Seeing How it Keeps Evolving*. (2010) Online at: http://www.apiweb.org/circling-back.pdf


Doctor
1
Tech
1
Nurse
1
Doctor
2
Nurse
2

Reason’s Swiss Cheese Model



Reason, James. *Human Error*. Cambridge University Press (1990)

Pachyderm

Anticoagulants and Communication

Why is this so complicated? I just want a piece of tissue!
I forget how many people "touch " the patient... to get this stuff done.

Frank Monroe, M.D.

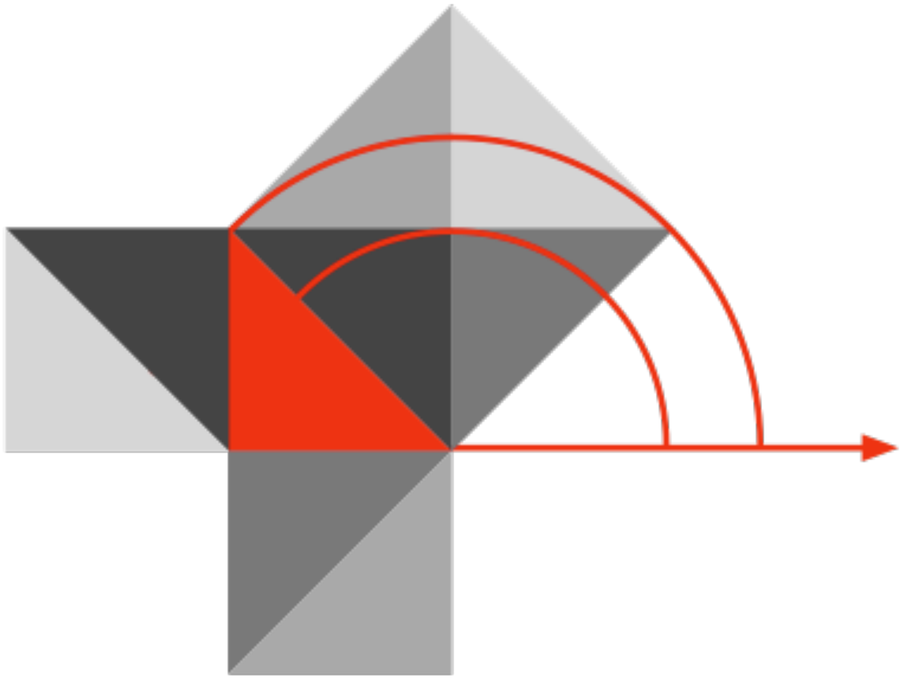
Expectation Disappointment Understanding Communication Appreciation

reset- 1 Mrs. Barlow

reset- 2 Janet Reed, R.N.

Drag zoom slider to enlarge image

Hippasus



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