

THE COLLABORATIVE ART OF TEACHING SCIENCE --- THROUGH DRAWING

Merrie Koester, Ph.D. USC Center for Science Education

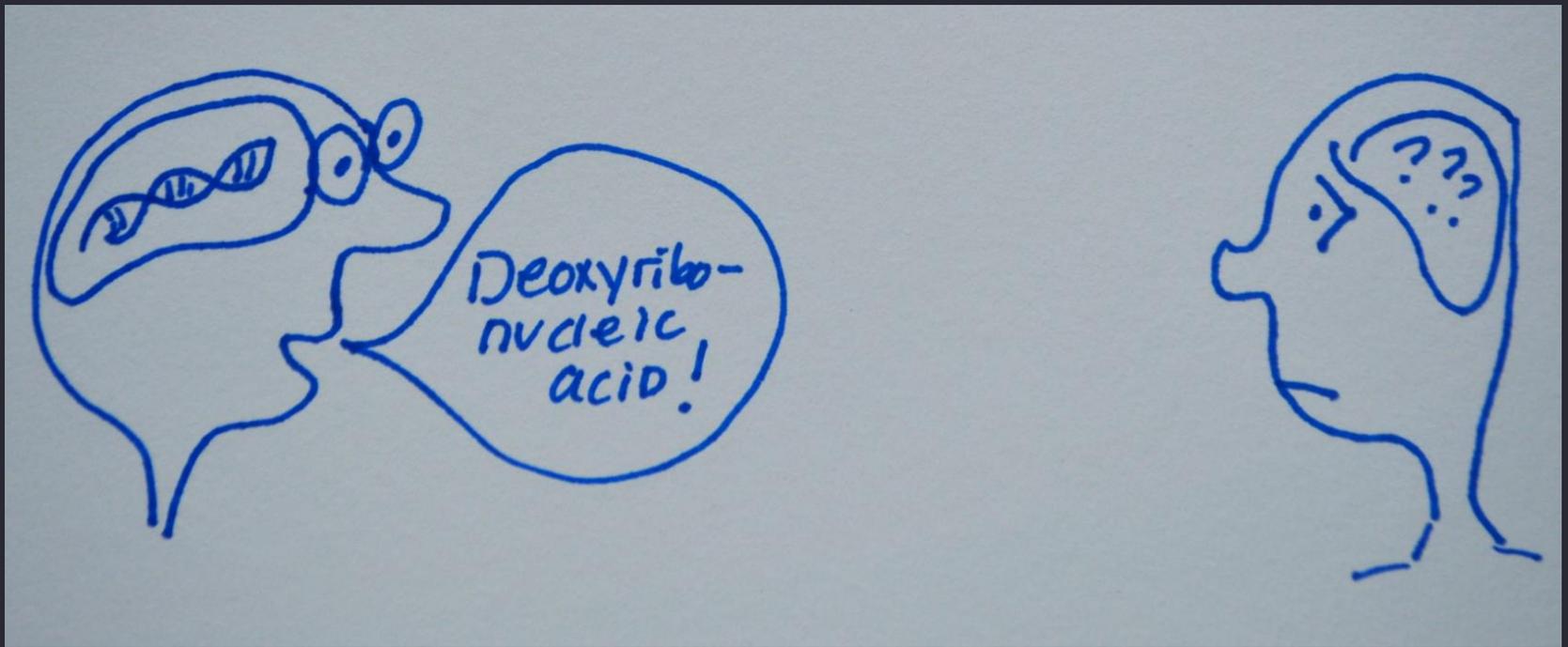
Seymour Simmons, Ed.D. Winthrop University Art Education

NAEA, Chicago, Saturday, 9:00 am, McCormick Place, North Building, N134

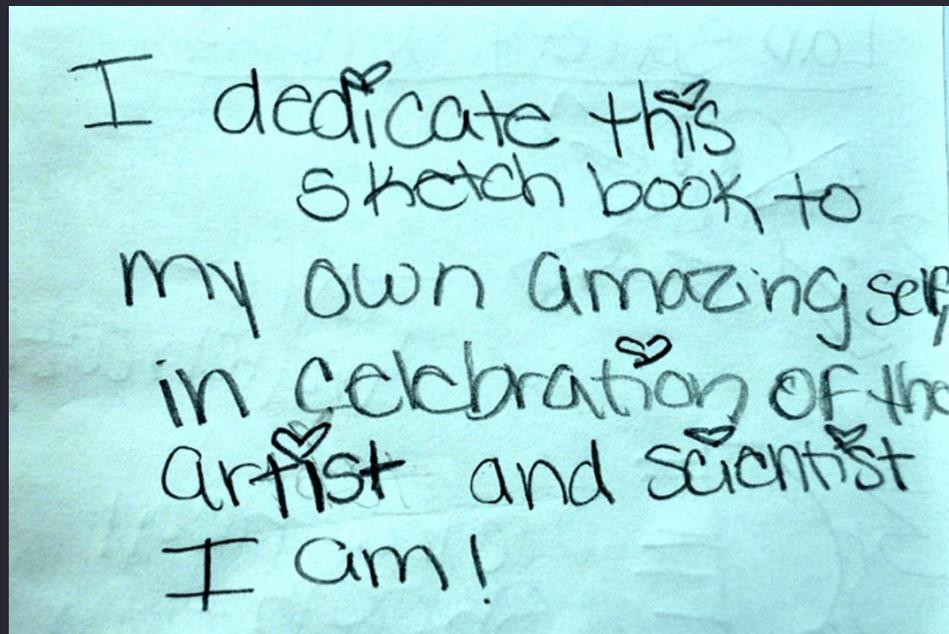
CREATIVE LEADERSHIP (the theme of this conference!)

- Challenges us to ADAPT, CONNECT, RELATE, JOIN FORCES, and POOL OUR RESOURCES. (Rolling, 2016).
- “Makes us agents of change rather than agents of the status quo”. (Kantawala and Rolling, 2014).

The “status quo” in a traditional lecture-based science class.



Making the Art and Science *CONNECTION*

A photograph of a piece of white paper with handwritten text in black ink. The text is a dedication to the author's self, celebrating their identity as both an artist and a scientist. The handwriting is casual and includes small heart symbols above certain words.

I dedicate this
Sketch book to
my own amazing self
in celebration of the
Artist and Scientist
I am!

*To draw something
is to know it.*

Leonardo da Vinci



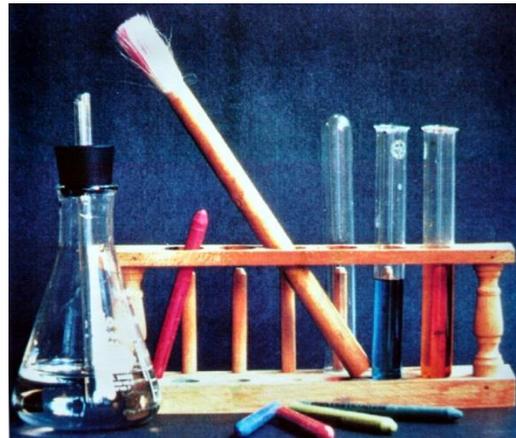
The artist who draws something without understanding the science of how it works is as uninformed as the scientist who relies only on theories and books. Each is like a sailor who tries to steer a boat that lacks a rudder or compass. Each needs to experience Nature directly through the senses. Leonardo da Vinci

Translation



**A ship without a rudder
will hit stuff.**

**Art and science
inquiry practices are
very similar.**



Art Studio Habits of Mind

- OBSERVING
- ENVISIONING
- INNOVATING THROUGH EXPLORATION AND DESIGN
- REFLECTIVE SELF-EVALUATION
- ENGAGING AND PERSISTING THROUGH MISTAKES
- CRITIQUING

Science and engineering practices (NGSS Standards)

- Ask questions and define problems.
- Develop and use models.
- Design solutions.
- Obtain, evaluate, and communicate information.

What do YOU think?

Making the Art and Science Connection

There are 7 “Cross-Cutting Concepts” in the Science Standards:

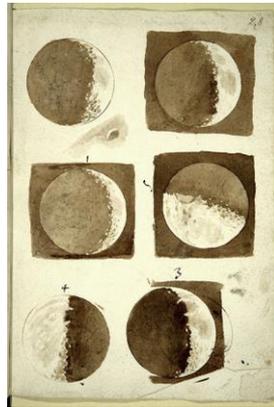
1. Patterns
2. Cause and effect
3. Energy and matter
4. Scale, proportion, and quantity
5. Structure and function
6. Stability and change
7. Systems and systems models

HOW MIGHT THE ARTS EDUCATOR TEACH THESE SAME SUBJECTS?

WILL YOU DESCRIBE A *HIGHLY EFFECTIVE* PROFESSIONAL DEVELOPMENT WORKSHOP WHERE SCIENCE AND ART TEACHERS WORK TOGETHER TO DESIGN CURRICULUM?

Famous Artist/Scientists who drew

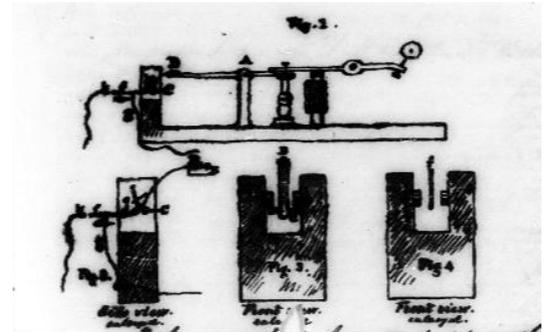
- Leonardo da Vinci
- Galileo Galilei
- Sir Isaac Newton
- Samuel F. B. Morse
- J. J. Audubon
- Charles Darwin
- Thomas Alva Edison
- F. A. Kekulé
- Nicola Tesla
- C. S. Peirce
- William James
- J. Watson and F. Crick
- Einstein



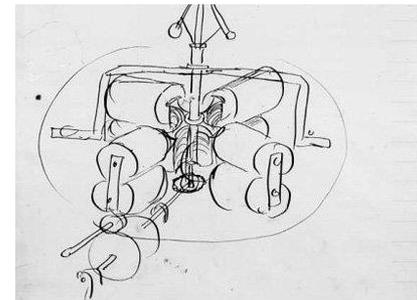
Galileo, 1609



F. Crick, 1953



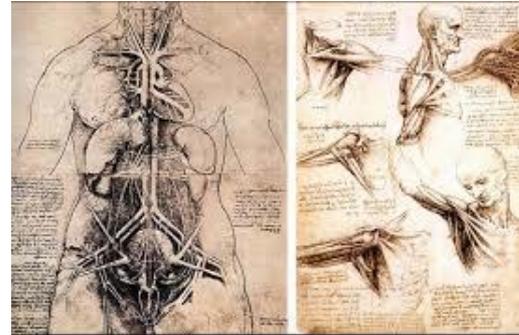
S. F. B. Morse: Drawings for the original telegraph



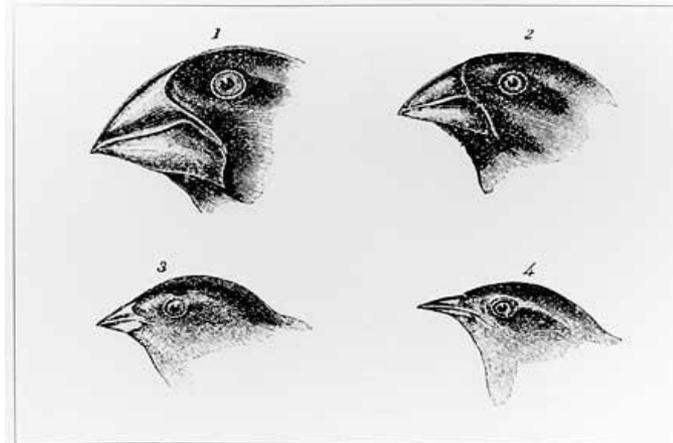
T. Edison: Drawing for a quadplex telegraph

Science fields that involve drawing

- Biological Sciences
- Medicine
- Physics
- Chemistry
- Engineering
- Invention
- Astronomy
- Geology
- Geography
- Psychology
- (Add to the list)



Leonardo da Vinci: Anatomical Drawings



Charles Darwin: Drawings of heads and beaks of Galapagos finches

Science still needs drawing: The design of engineering solutions.

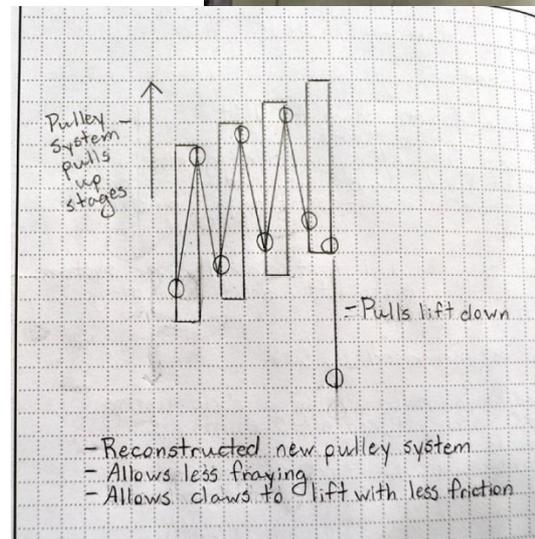
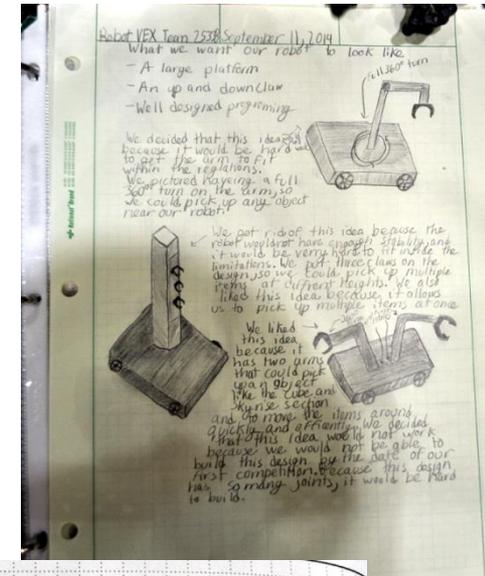
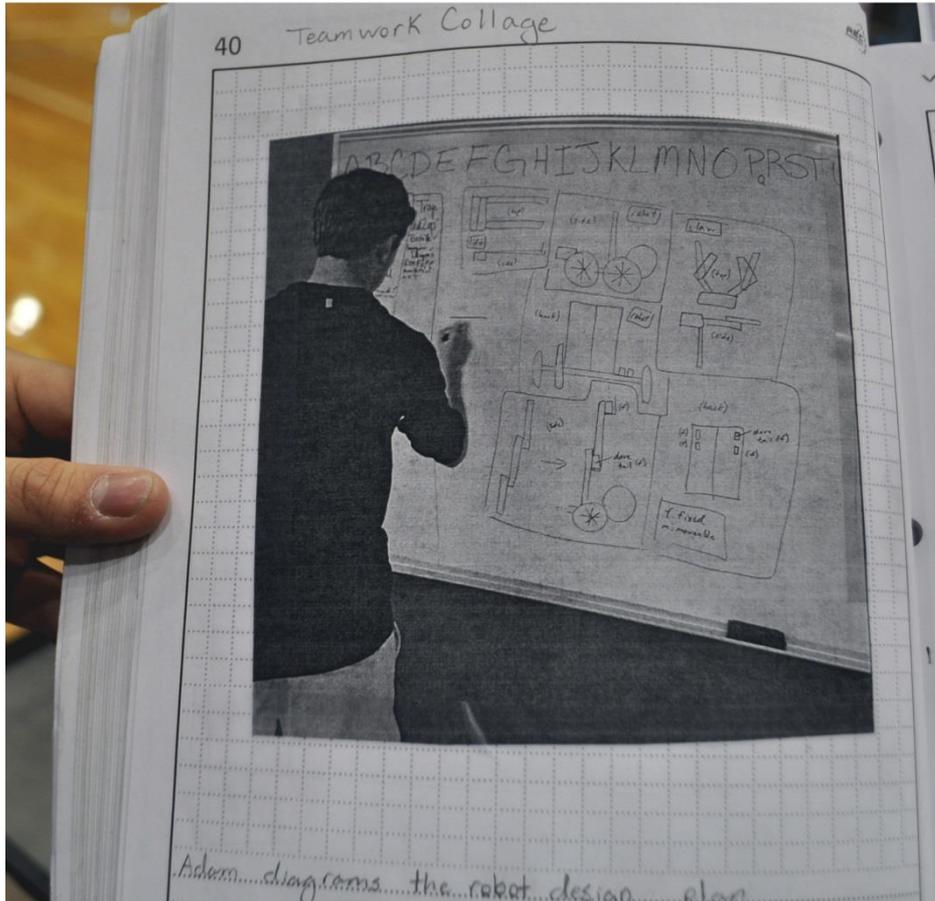
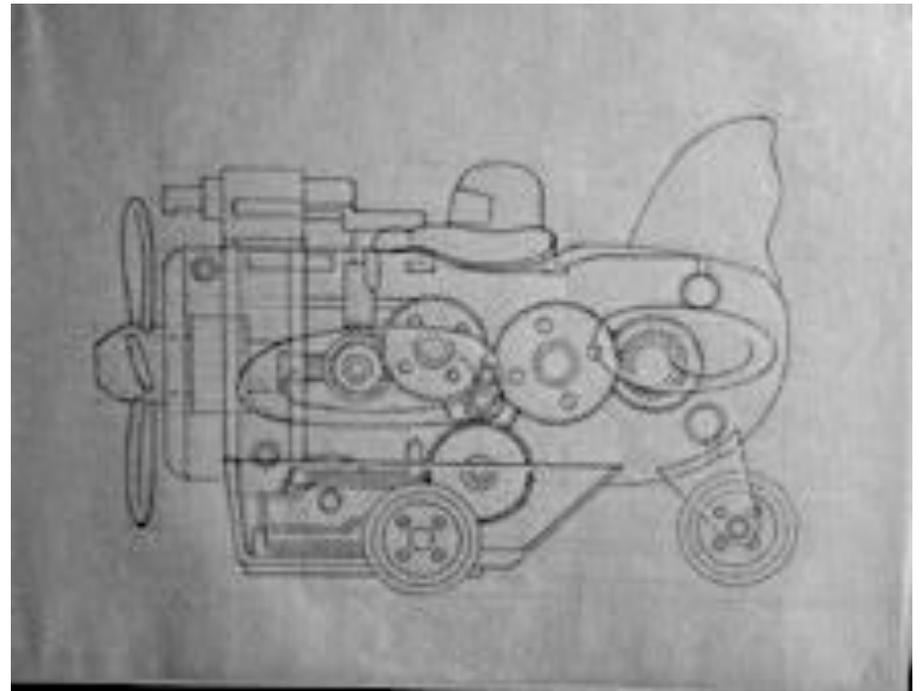
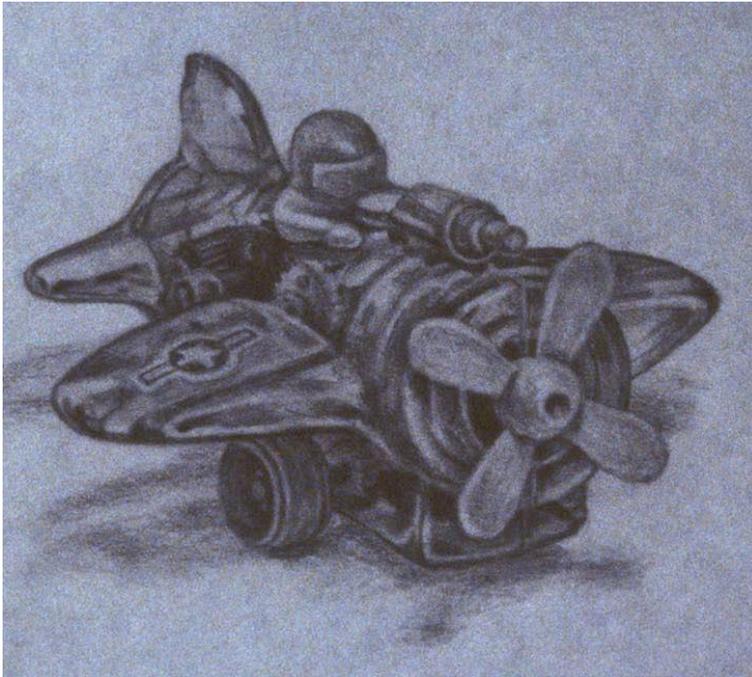
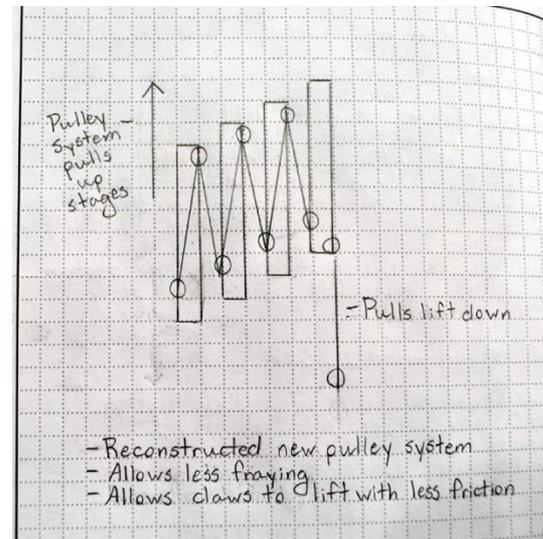
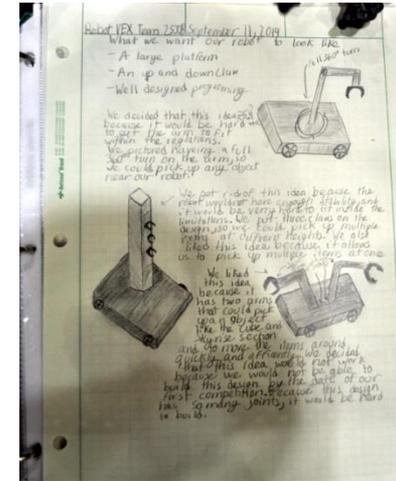
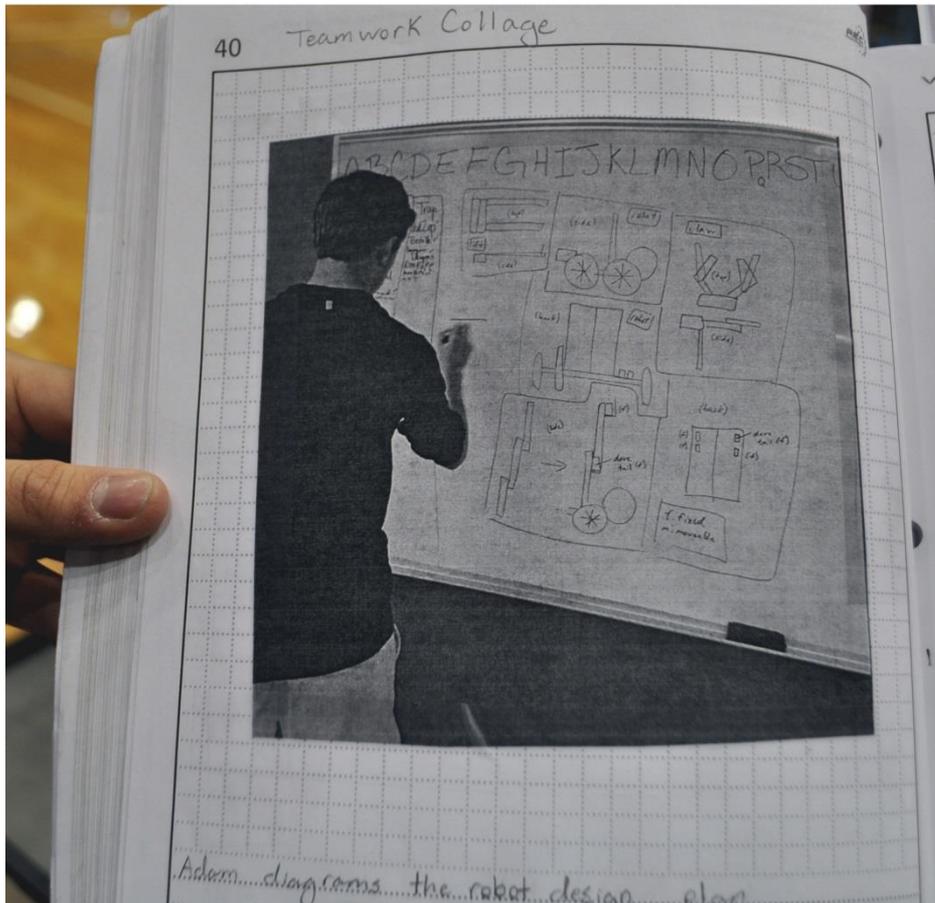


Illustration FOR Mechanical SCIENCE: College Level

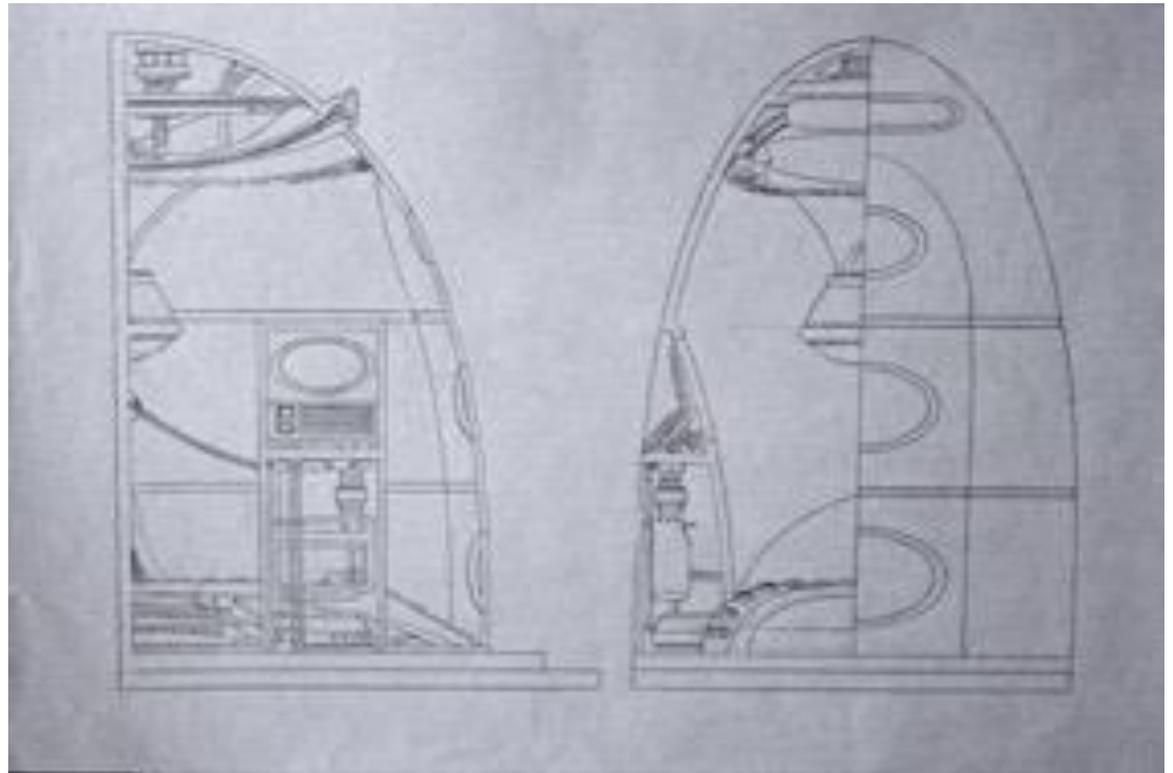
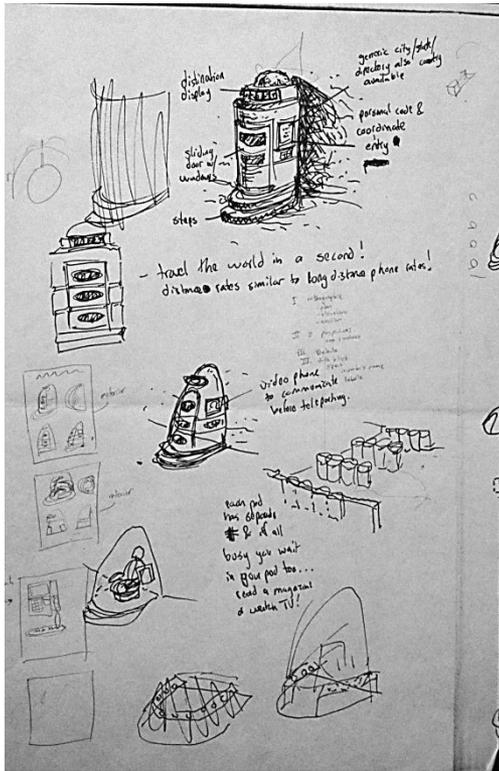


Mechanical Toy: Observational Drawing to Cross-Section Schematic

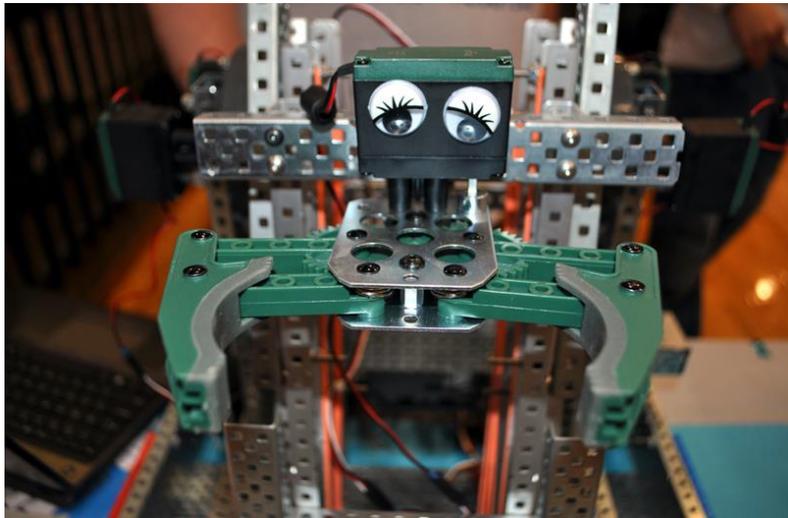
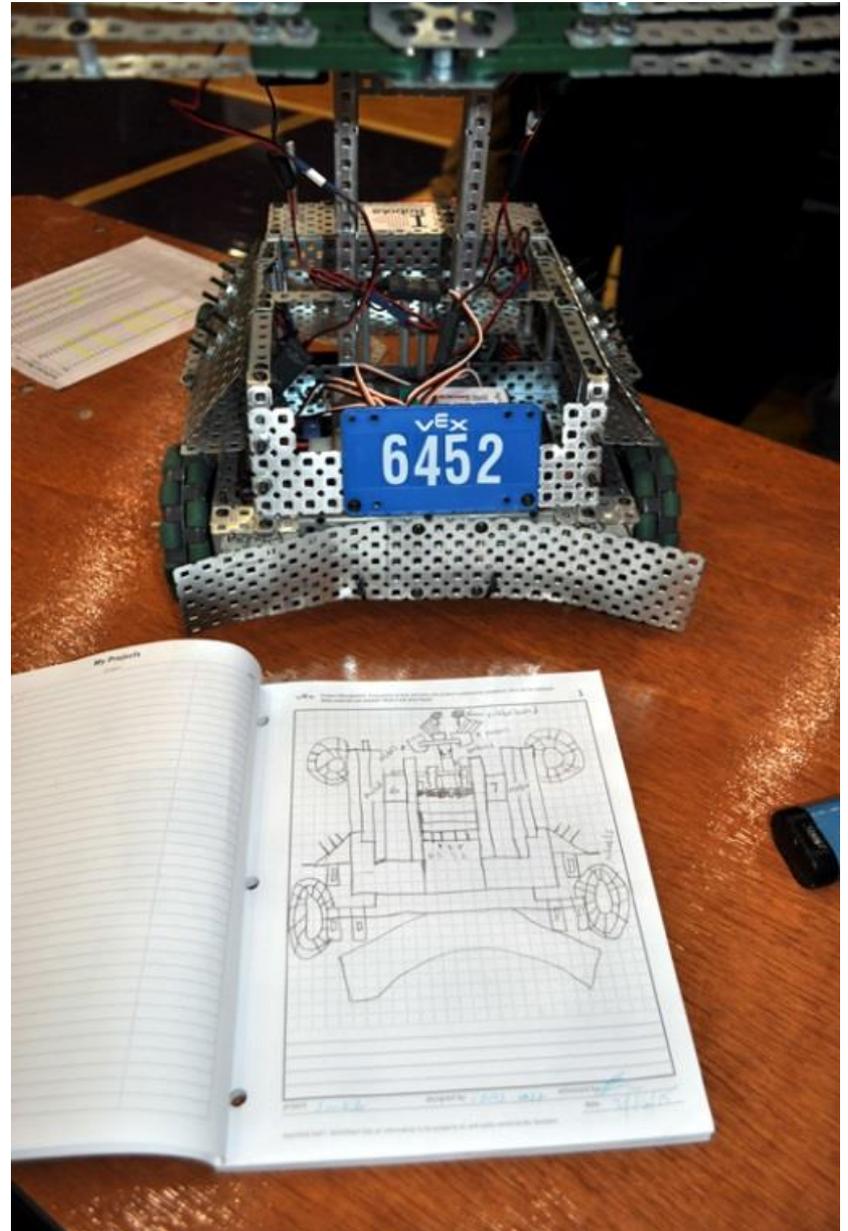
Drawing is essential in the design of engineering solutions.



Invention: College Level

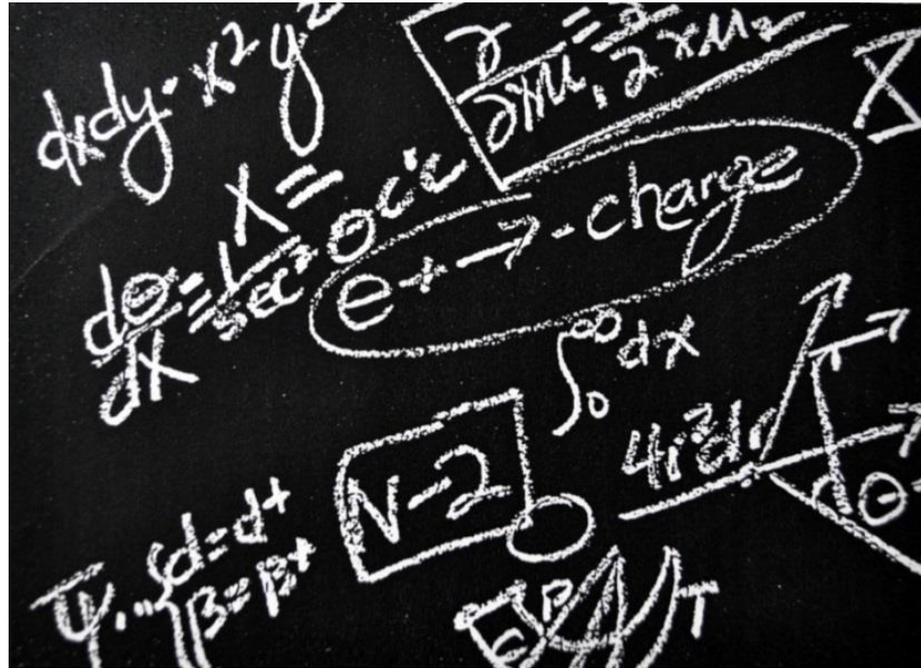


Time Machine: Concept Sketches to Cross-Section Schematics



The Problem of Language and Communication

- Most science teachers have had little to no training in drawing or the art of visually organizing information.



Virtually all teachers have students who are...

- are reading below grade level.
- are English Language Learners
- have special needs.



“One in five children in the U.S. struggles with issues related to reading, writing, math, focus, and organization. These kids are as smart as their peers.

But they are not getting the support they need to succeed...Only 68% of students identified as having specific learning disabilities like dyslexia graduate from high school. 19 percent of students with learning disabilities drop out.”

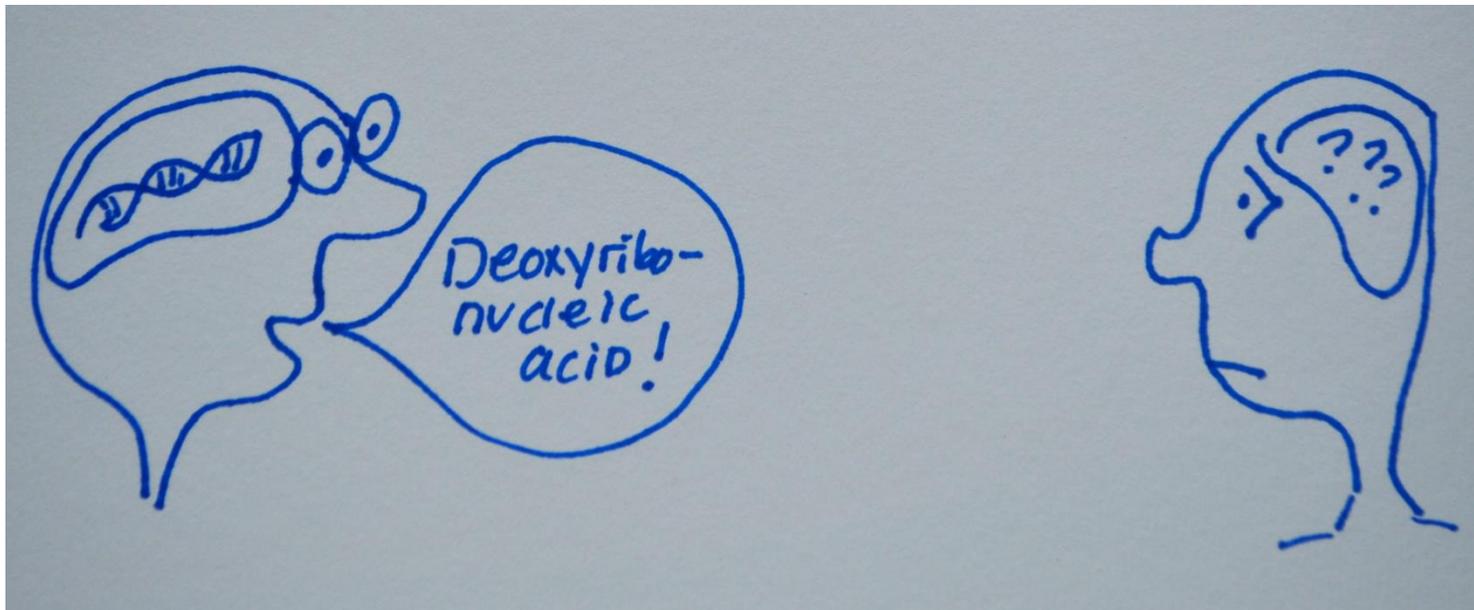
www.understood.org

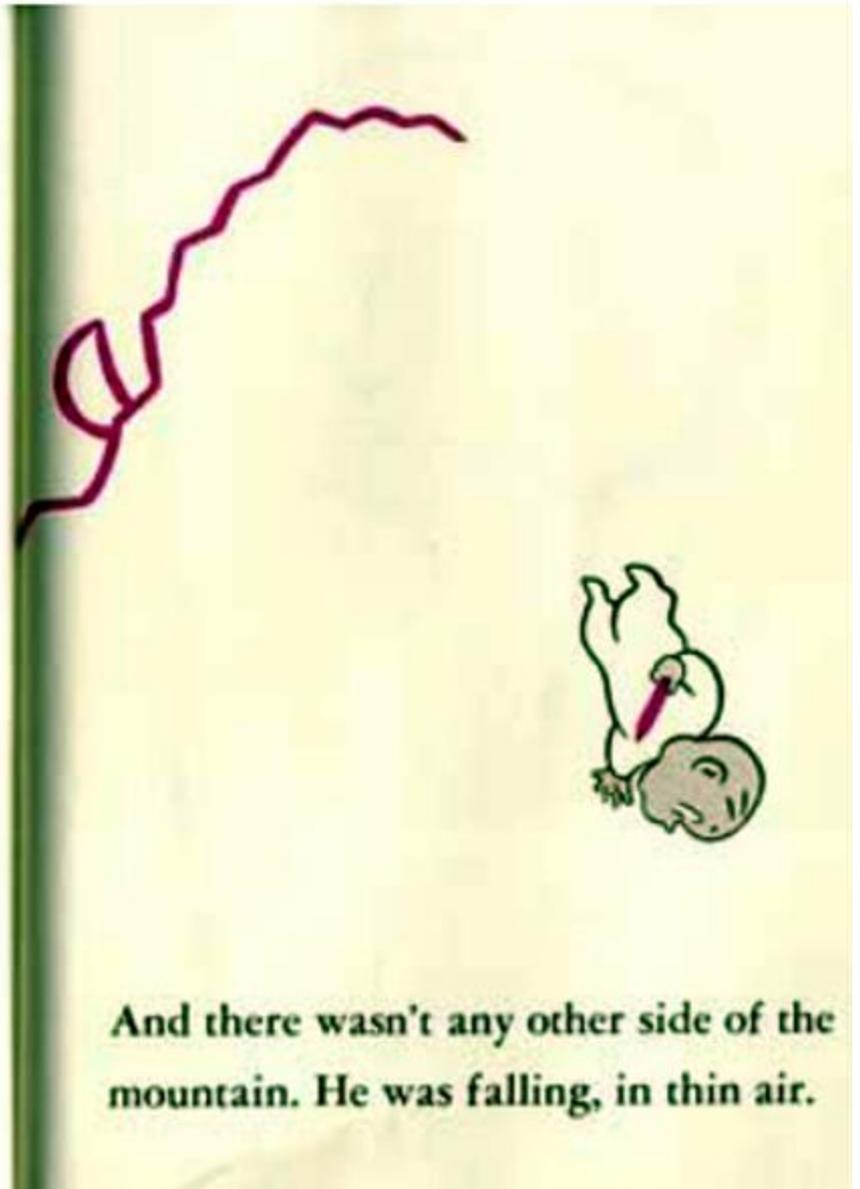
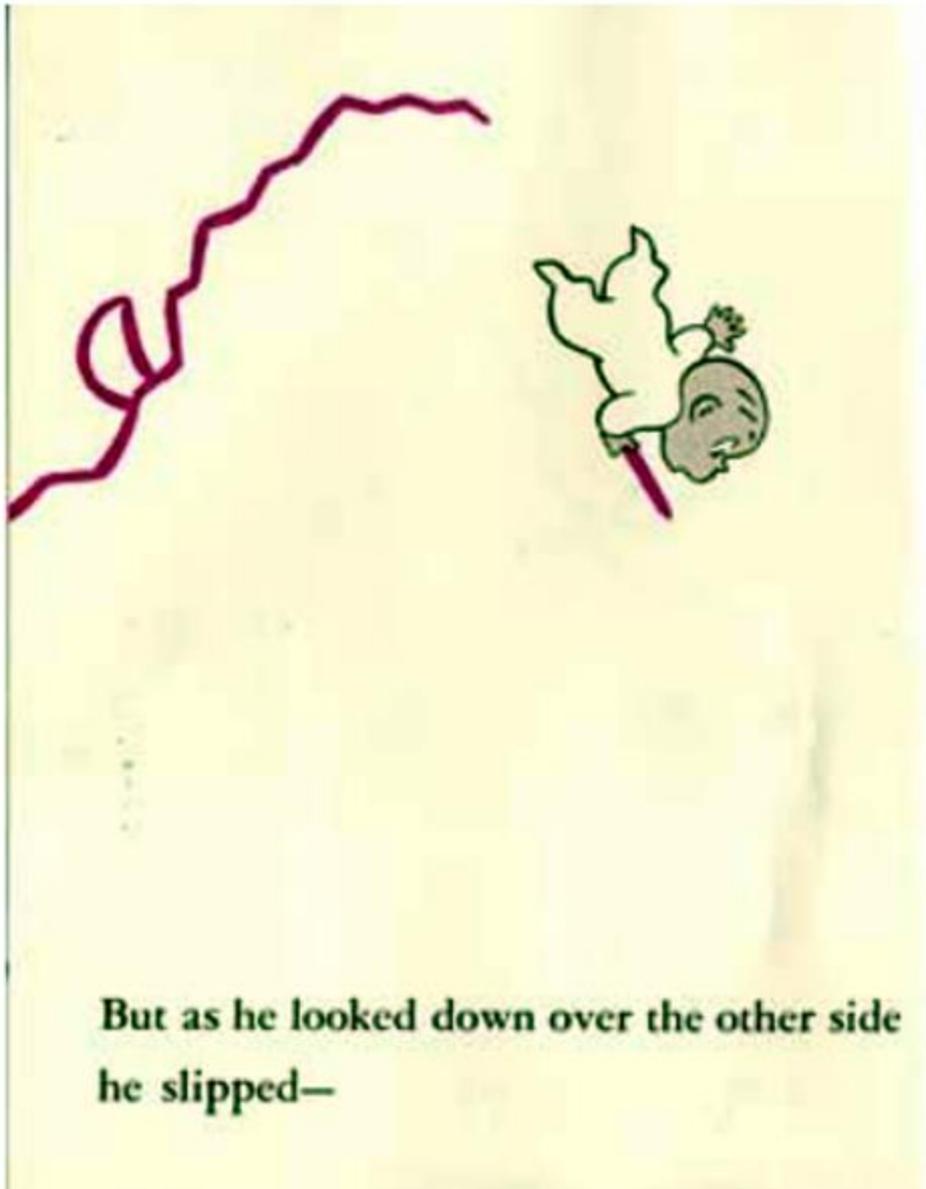
Some descriptive statistics

NAEP 2011 Science and Reading Assessment Summaries
For **8th grade students**

Student category	% scoring below basic in READING	% scoring below basic in SCIENCE
All Students	25	36
Low Income Families	37	52
English Language Learners	71	83

When achieving science literacy depends primarily on reading and listening fluency, there can be profound problems.





What is must feel like to be a struggling reader in a lecture-based science class.

For the purpose of science – whenever the student cannot be expected to discern the real thing by him/herself, the educator needs to [be able to] provide a sufficiently simple version of the final image.

- Rudolf Arnheim, *Visual Thinking*

CSE

Center for Science Education

Project Draw for Science



MAKING SCIENCE VISIBLE FOR ALL STUDENTS.

- The belief that the arts connect, communicate, and break down barriers, opening windows to the world.
- The inclusion of arts practices in the teaching, learning, and application of the Next Generation Science Standards (NGSS).
- Less emphasis on teacher-telling what is "right" or "known" and more time devoted to collaborative, design oriented thinking and performance based assessments.
- The belief that drawing instruction and practice should become an integral part of a school's STEM education program and curriculum as well as science teacher preparation.

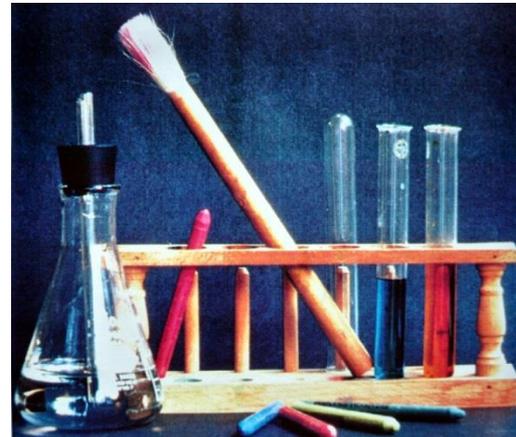
How STEAM is conceptualized in the Project Draw for Science Action Research.

<http://merriekoester.wix.com/project-dfs>

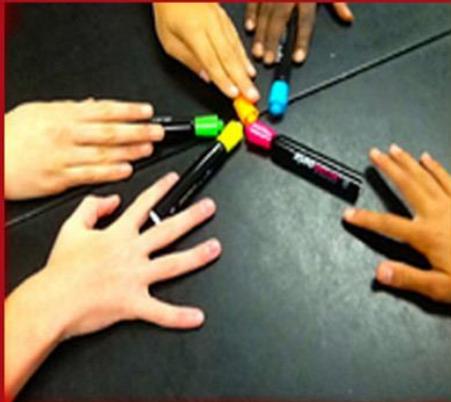
Project Draw for Science

RESEARCH QUESTION

What will happen when science educators acquire the *capacity* to teach through **drawing**, using **pedagogy** which is also **aesthetic**?



THE TRUE STORY
OF HOW DOING ART
CAN MAKE
SCIENCE MATTER
TO MORE STUDENTS



Science Teachers Who Draw:

The *Red* Is Always There



Merrie Koester

Deep University Press

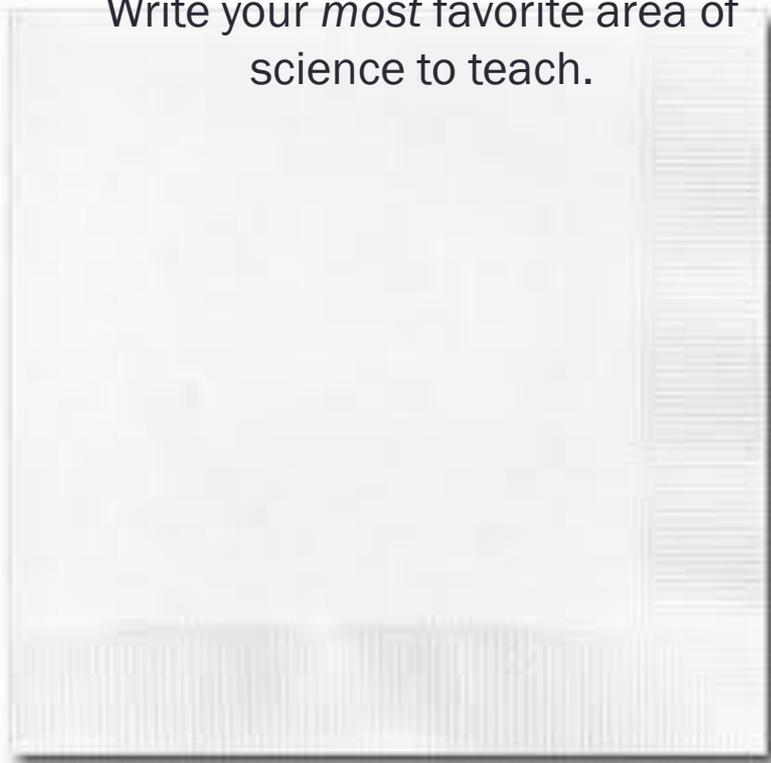


Making Science **VISIBLE
for ALL Students**

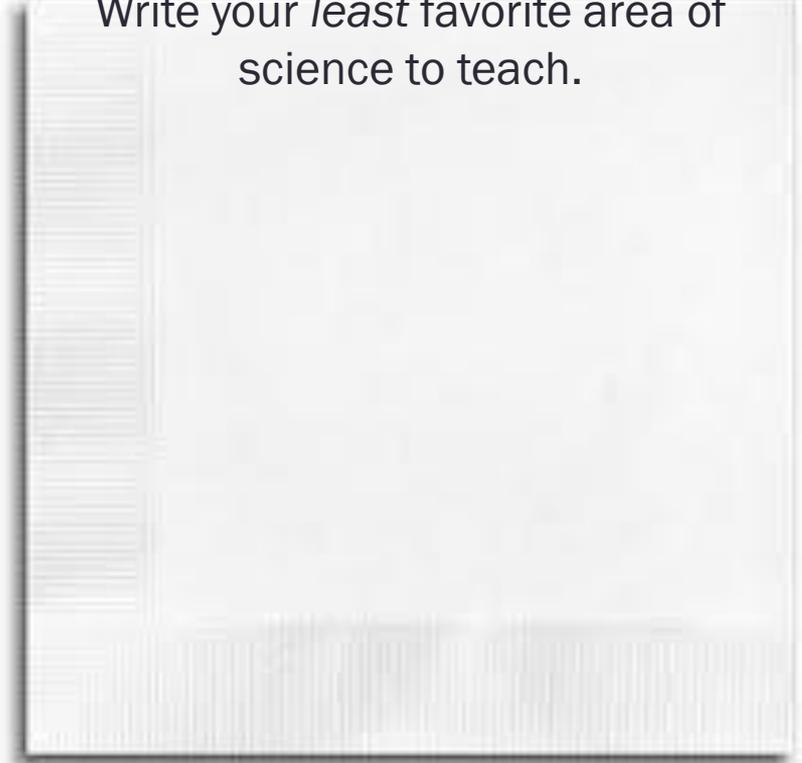
**Research Finding: Drawing
deepens teacher content
Knowledge.**

The Back of the Napkin TEST

Write your *most* favorite area of science to teach.



Write your *least* favorite area of science to teach.





Most middle and elementary science teachers could draw very little on topics related to the physical sciences.

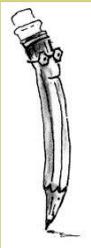
Research Finding

**Drawings have a
high sticky factor.**

Picture Superiority Effect

- New words/concepts are more likely to be remembered when they are presented as pictures rather than with words alone.

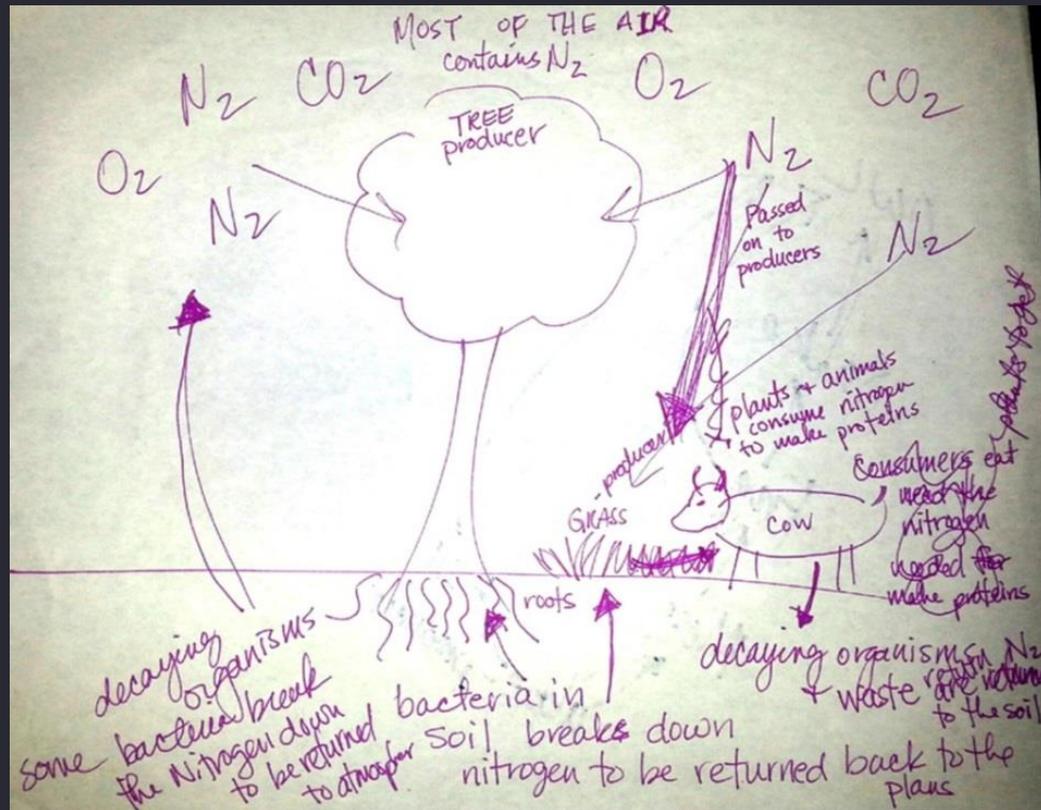
Paivio & Csapo, 1971



Picture Superiority Corollary

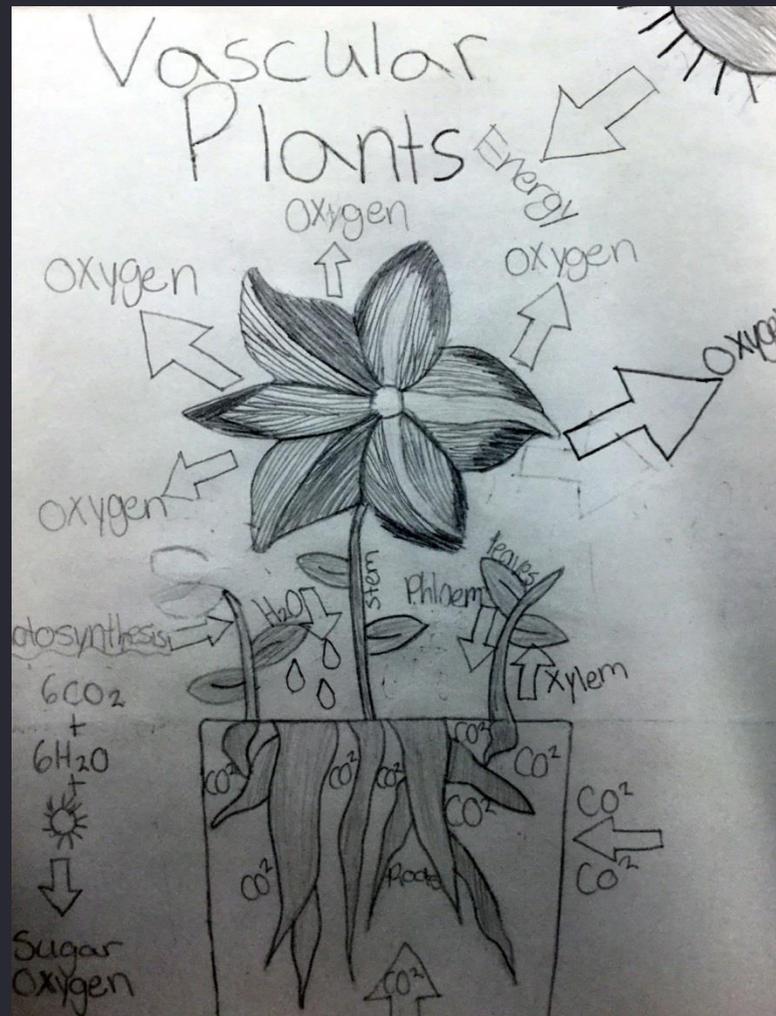
- *Unlearning* a concept which has been incorrectly presented through drawing is far more difficult than unlearning a concept which has explained through words alone. Also, directional arrows are powerful, symbolic communicators of information and must be used judiciously.

What's wrong with this picture?



This science teacher inadvertently had an entire class drawing a misconception about the nitrogen cycle.

Teacher often failed to pick up the student misconceptions:



Theory of Aesthetic Masking

- *A teacher can be so distracted by the aesthetic appeal of a science drawing that he or she fails to recognize misconceptions which may be re-presented there.*

Koester

Most science is taught through talking and telling...



An anesthetic experience.

What if?

- *What If* **STEM** and **Arts** educators worked *together* to *cross-train* each other on behalf of their students?
- You get *DEEP* **STE**[**A**]**M**!

The art educator simultaneously teaches elements of design.

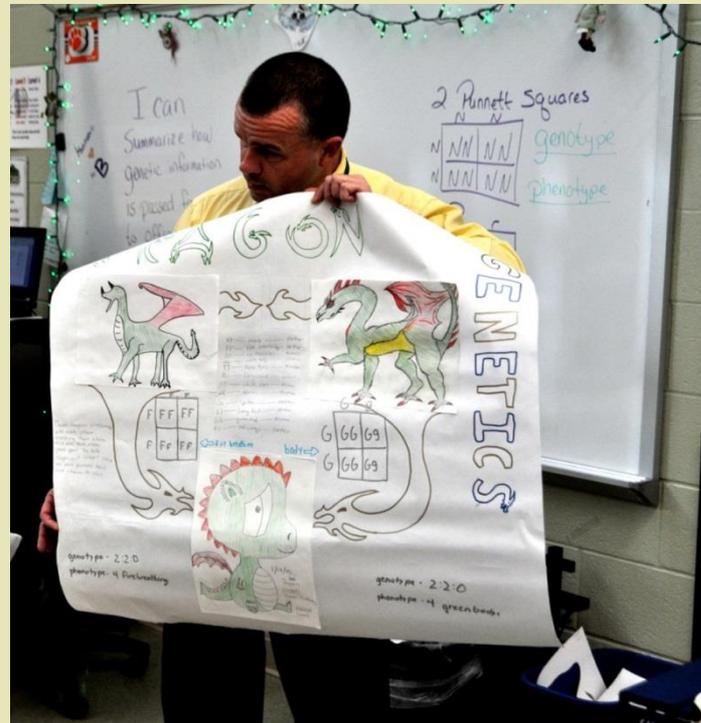


So nice

Science teachers and students design

“KNOW”tations, using elements of graphic design to communicate their understanding of situated science learning.

The science teacher also learns to use graphic design vocabulary.



What happens in the “Know”tation?

Explanatory **IMAGES**

connect

WORDS,

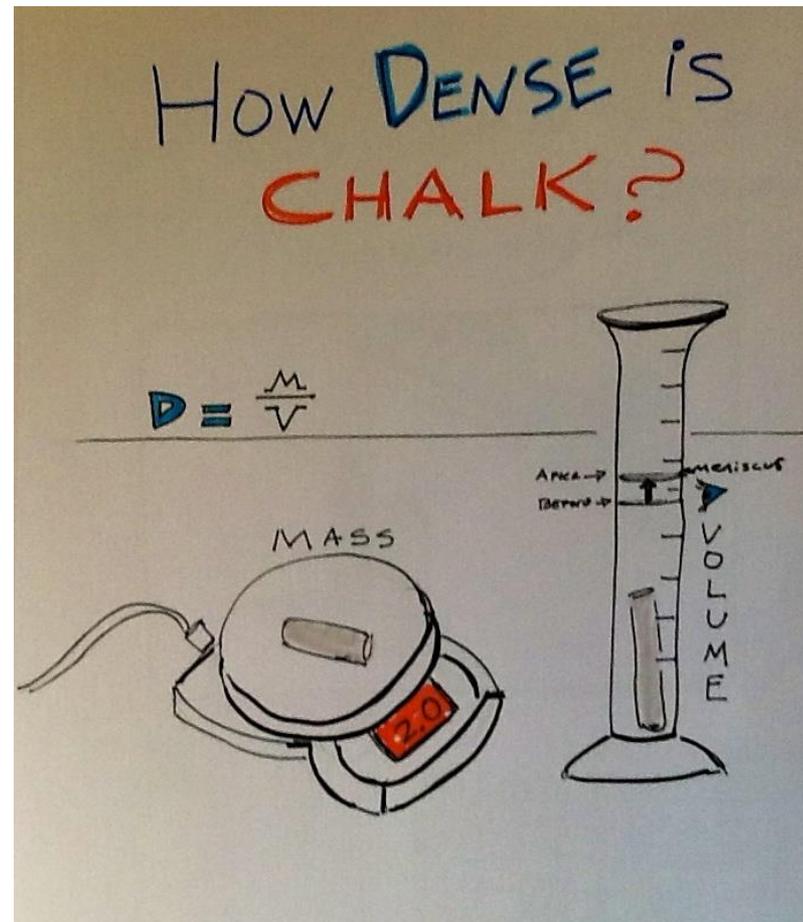
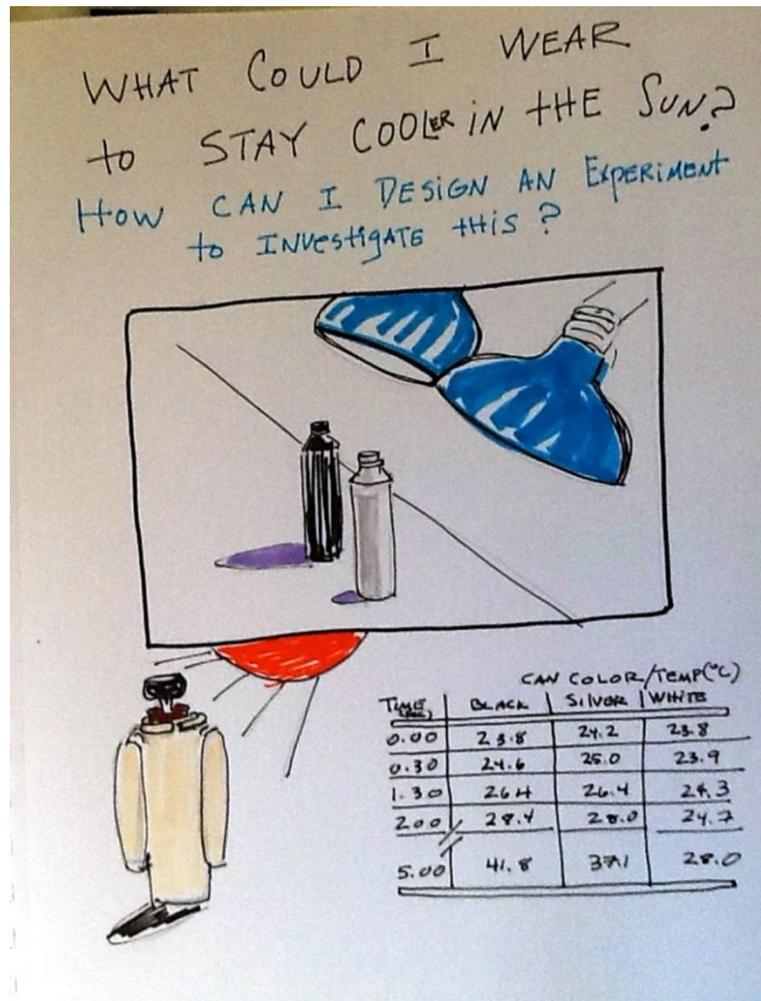
SYMBOLS,

and **ACTIONS** of **SCIENCE**

through

visual narrative.

You get meaningful artifacts like this:



“Know”tations...

- Are acts of critical, creative *making*, the kind Seymour Papert (1991) had in mind when he developed his theory of constructionism. They are “public artifacts,” compositions that inform and transform learning by being made in the first place.



Project Draw for Science

STEAM Professional Development

- Project Draw for Science workshops focus on improving teacher content knowledge across *both* arts and science standards.
- Science teachers learn the art of creating “Know”tations, while arts teachers guide students and their science/STEM teachers toward improving/revising their visual explanatory models and drawing skills.
- Collaborations can’t be framed *only* in terms of communicating science/STEM and must also foreground arts studio knowledge and practices.
- Involves arts, science, STEM, and STEAM educators working collaboratively, especially in the writing of grants to fund ongoing action research.
- Values collective over isolated impact.

• © Merrie Koester, Ph.D.



Making Science VISIBLE
for ALL Students

RESEARCH CLAIMS

- **DRAWING**, conceptualized as a meaningful science **LANGUAGE**, should be an integral part of an **INCLUSIVE SCIENCE EDUCATION**.
- The “**Know**”**tation** is a meaningful, purposefully constructed, **RE-PRESENTATION** of **SCIENCE KNOWING** that can be used as a performance assessment.
- The **best results** can be achieved when **science and arts teachers work together**.

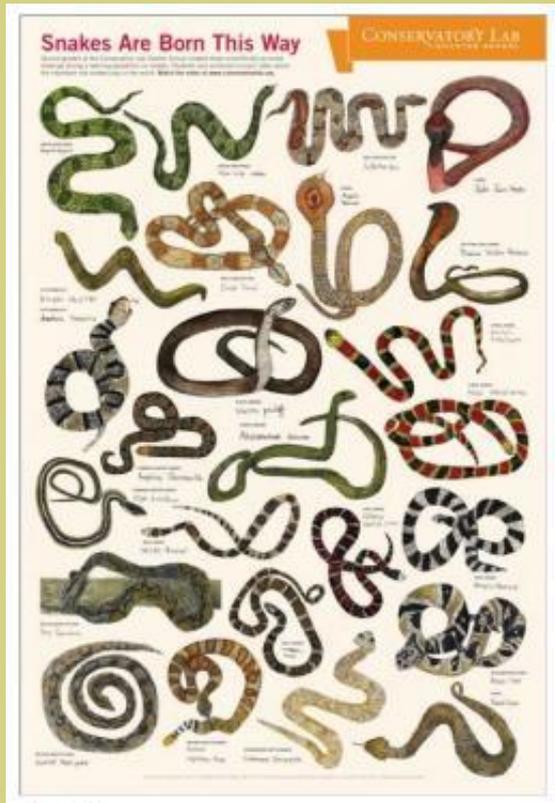
Drawing Across the Curriculum

A National Art Education Foundation
Research Project

Andrea Kantrowitz
Teachers College, Columbia University

Seymour Simmons
Winthrop University

BIOLOGY FIELD STUDY 2nd Grade

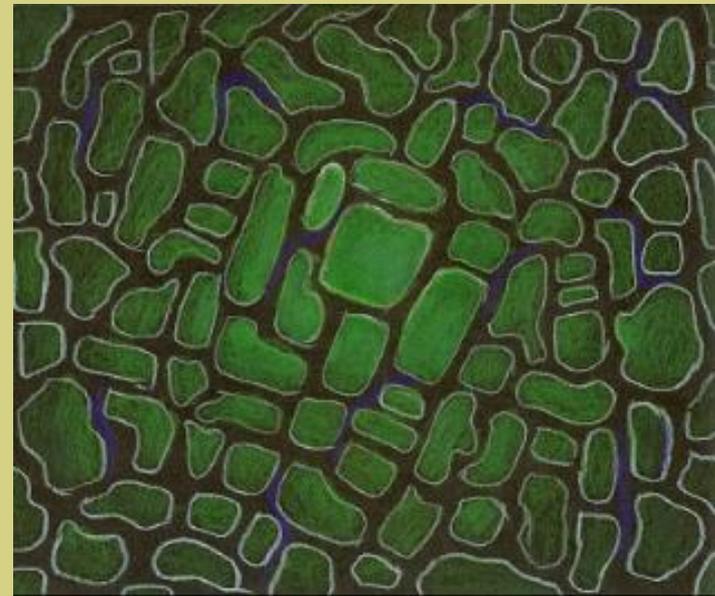
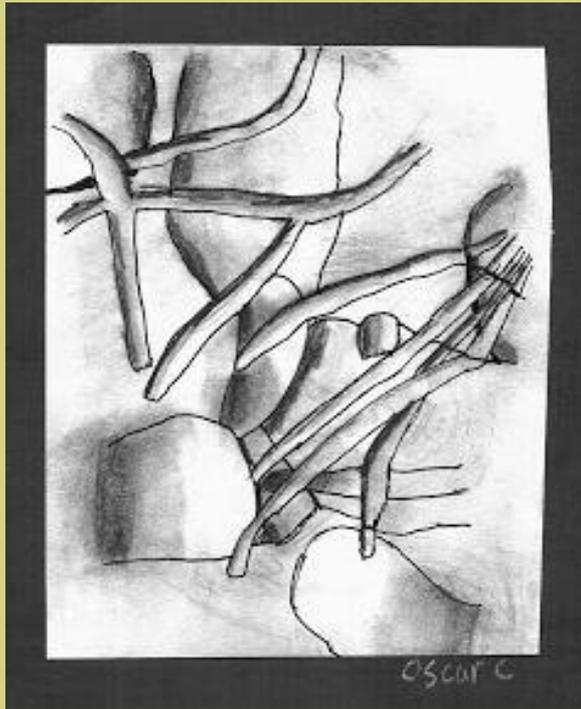
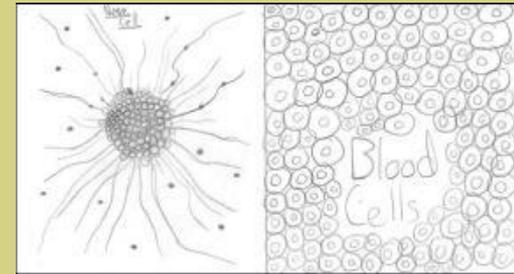


Studying
Snakes



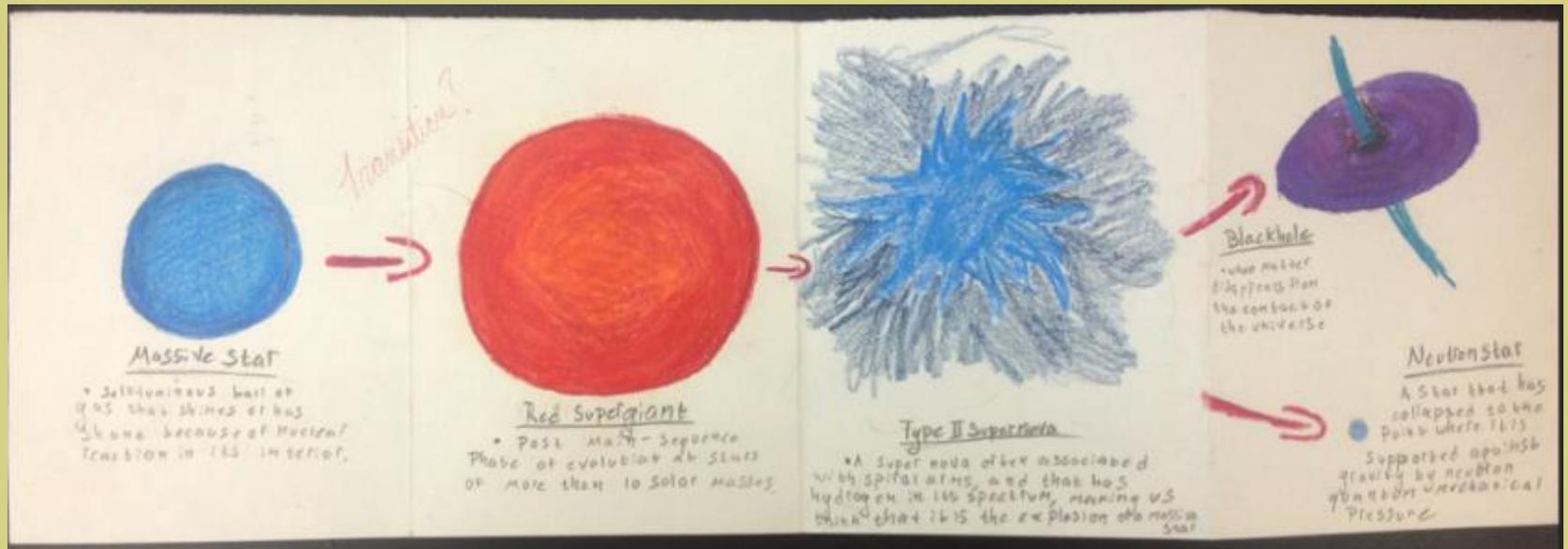
New England Conservatory Lab Charter School, Boston, MA
Jenna Gampel, 2nd Grade Teacher

CELL BIOLOGY: Middle School



Escuela Campo Alegre, Caracas, Venezuela
Michael Anderson, Art Teacher
Adam Fox, Abram Cosby

ASTROPHYSICS: High School



Marlborough High School,
Marlborough, MA
Kristi Oliver, Art; Nicole Shanks: Science

DATA: VOICE WORDLES

- How did learning science through drawing make you feel?
- How did it affect your academic achievement?



**Making Science VISIBLE
for ALL Students**



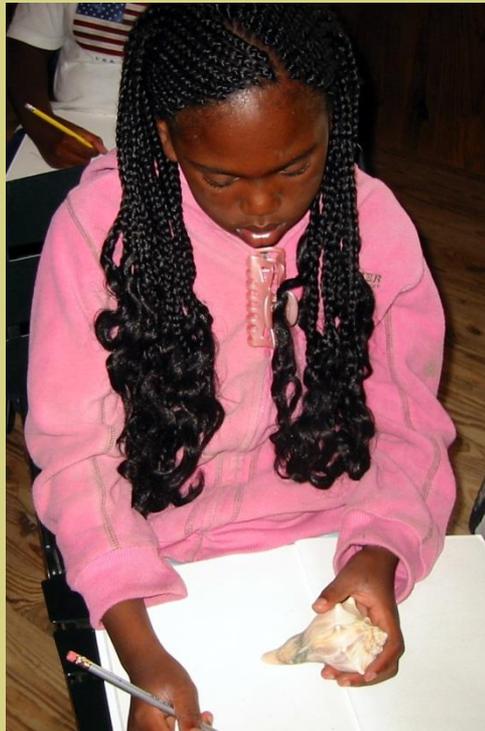
Making Science **VISIBLE**
for ALL Students



The *Feelful* Wordle

CLAIM

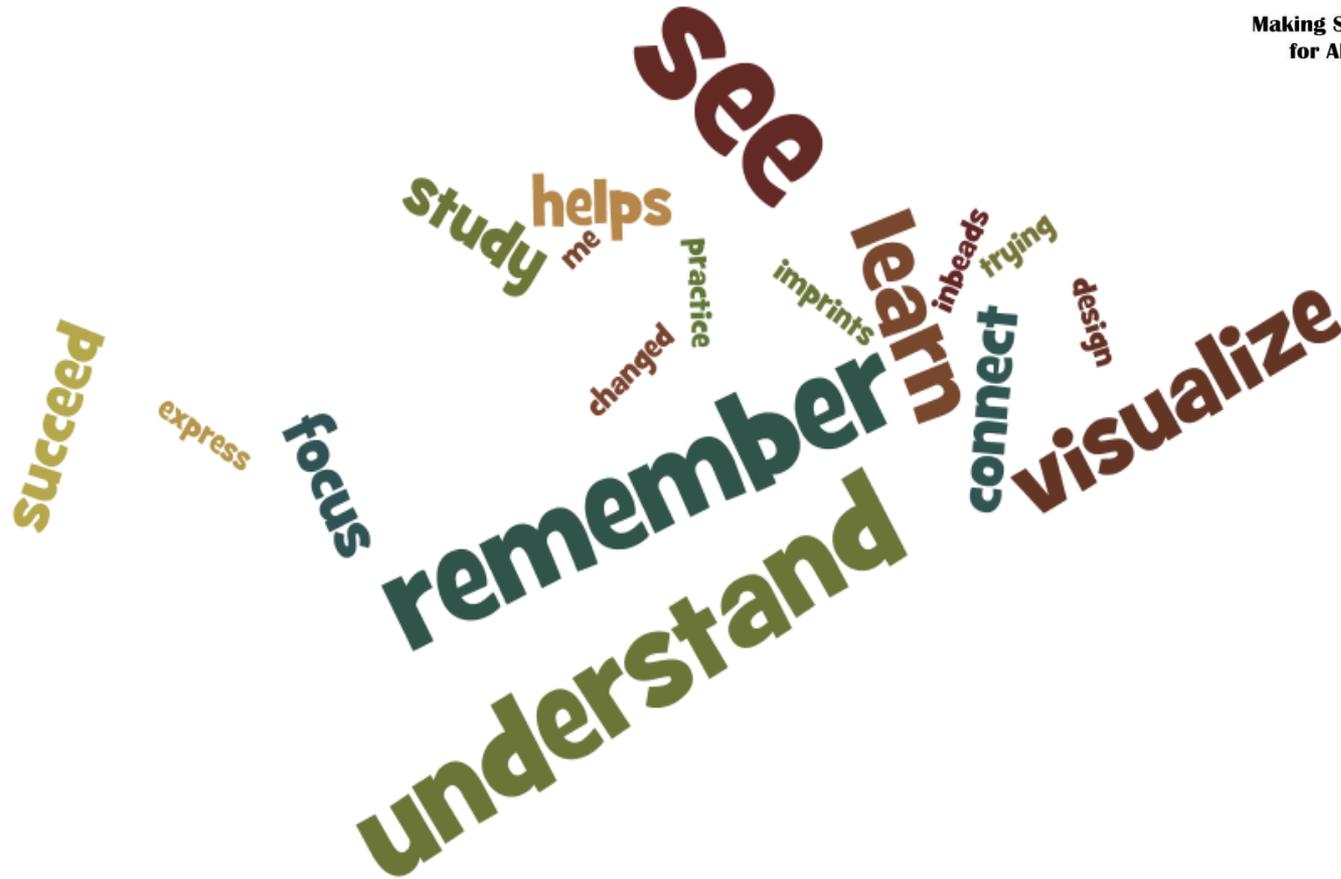
Aesthetic inquiry can move the student away from ALIENATION and towards AFFILIATION.



Linking drawing to academic achievement

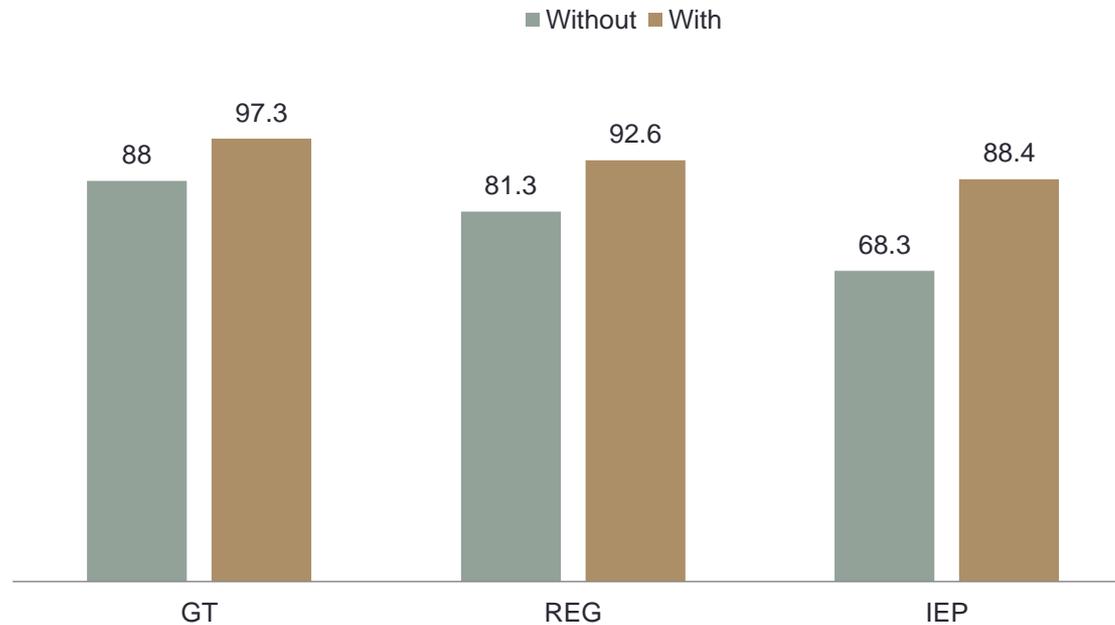


Making Science **VISIBLE**
for ALL Students



The *Action* Wordle

Mean Test Scores by Ability Group Without and With Drawing Project

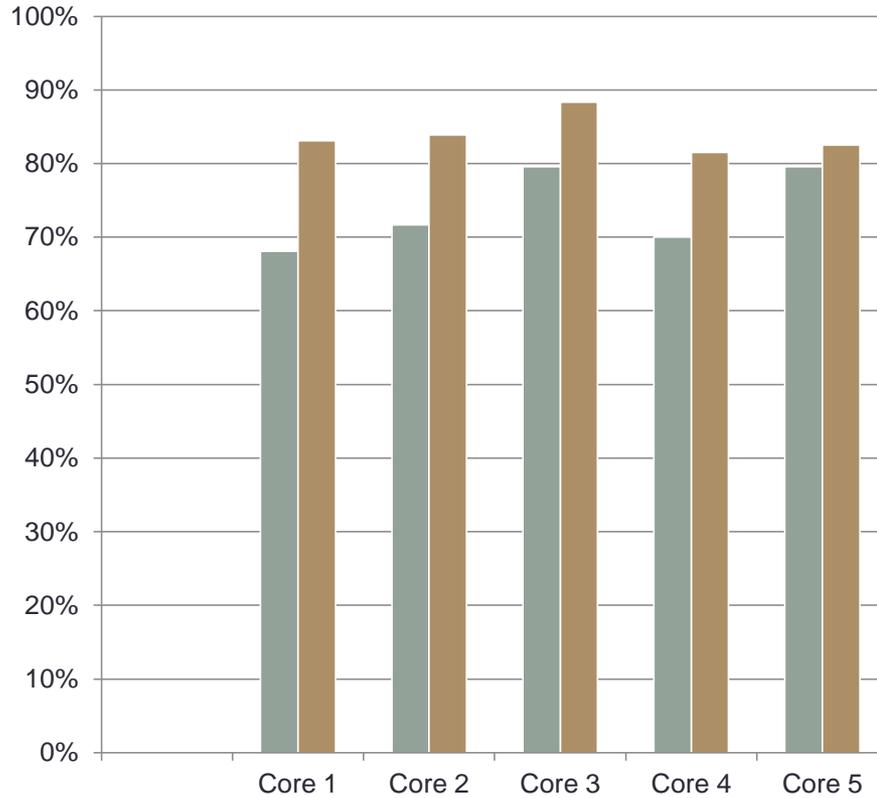


Test scores on a standardized ecology unit test
across identified ability groups



**Making Science VISIBLE
for ALL Students**

Student Quiz 1 Grades Compared to Quiz 2



Pre-drawing

- Worms/Sponges Quiz
- Echidorms/Mollusk Quiz

**Making the Art
and Science
*CONNECTION***

*How can we put drawing and making
in the middle of **science and art**
teaching and learning.*

The Art-Bot as Art/Science



What do YOU think?

Making the Art and Science Connection

There are 7 “Cross-Cutting Concepts” in the Science Standards:

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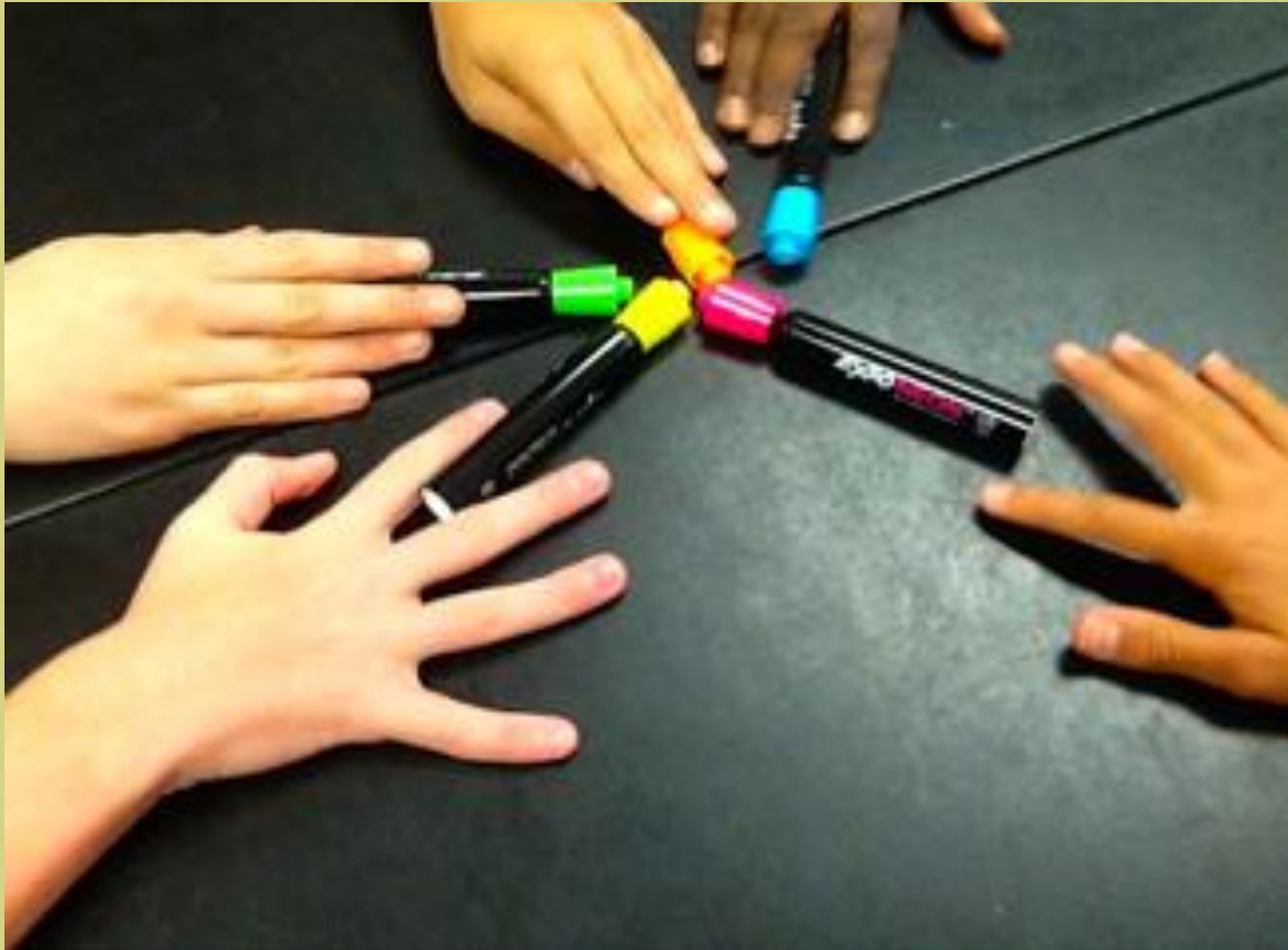
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Drawing Matters!

However you conceptualize **STEAM**, we believe drawing needs to be an integral component of the **Seeing, Thinking, Knowing, and Doing** of the **Learning** of science/STEM.

Will you help us keep this conversation going by sharing your own Drawing to See, Think, Know, and Do lessons at <https://www.facebook.com/scienceteacherswhodraw/> ?



On your mark, get set...