

Engaging Your Students in Primary Research

How can teachers engage students in
primary research as a means to
cultivate scientific leaders for the
21st century?

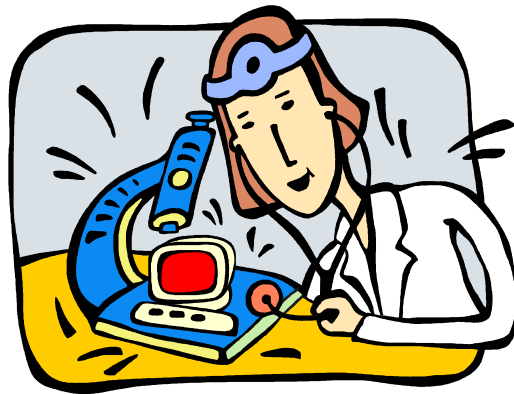
Workshop Focus

- Why primary research?
- Encouraging curiosity
- Developing the skill set
- Conducting research
- Presenting findings

Why Primary Research?

- To cultivate the next generation of scientists, engineers, inventors, and economic leaders
- Next Generation Science Standards place a heavy emphasis on hands-on and experimental learning in an attempt to produce high quality, college- and career-ready students and future scientists

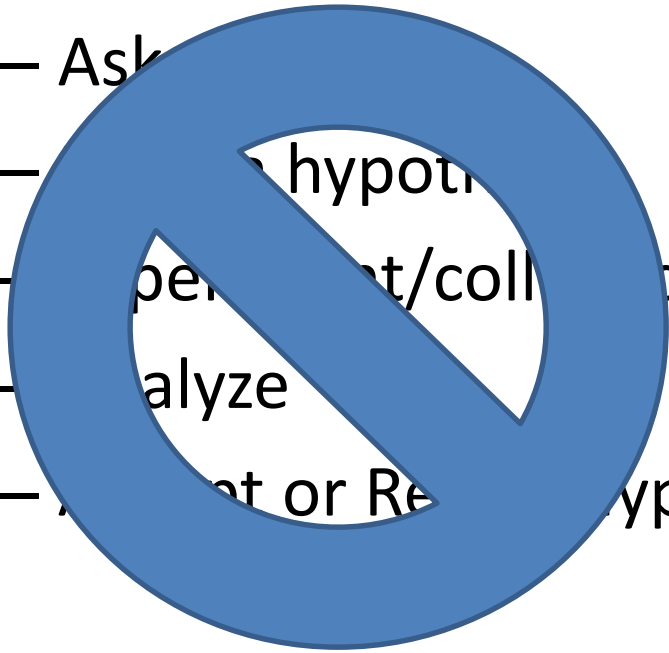
Why Primary Research?



Students and *The Scientific Method*

- At a young age students are taught (and probably expected to memorize) the steps

- Ask
- Formulate a hypothesis
- Experiment/collect data
- Analyze
- Conclude or Re-evaluate hypothesis



From howstuffworks.....

Scientific Method Steps

As more proof that there is no one way to "do" science, different sources describe the steps of the scientific method in different ways. Some list three steps, some four and some five. Fundamentally, however, they incorporate the same concepts and principles.

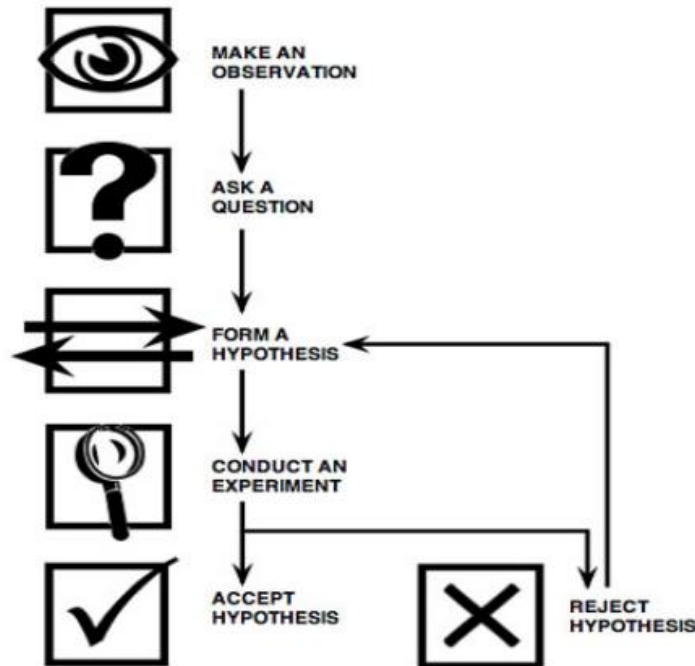


Image courtesy William Harris

For our purposes, we're going to say that there are five key steps in the method.

Encouraging Curiosity

- Labs and demos
- Science Mysteries
 - Adapted from a model presented by John Mauch at a Flinn Workshop
- Students are engaged by:
 - Making observations
 - Asking questions
 - Developing a hypothesis
 - Thinking of tests for the hypothesis

Developing the Skill Set

- Use flow charts for teacher-directed labs
- Real-time data collection
- Supports careful observation

First Year Chemistry Research

- 10th / 11th grade Chemistry
 - ***Chemistry Day Project***
 - Two term project
 - Begins with secondary research paper
 - Scope limited to chemistry, but students pick topic
 - With careful structure and planning, this can be accomplished without dominating your class time!
 - Term three project is a long-term experiment that culminates in Chemistry Day

Chemistry Research Paper

- Assignment given a week or two before going to library
- Students given examples of topics from previous years
- Given a brief explanation of term 3 since term 2 lays the foundation
- Papers are written in MLA format
- Assignment is chunked in segments to allow teacher to give support
 - This ensures a better paper – making it beneficial for student AND more enjoyable to read and grade!

Conducting Research

- Assignment given at beginning of term 3
- Project is chunked with stepwise deadlines
 - Preliminary protocol design
 - Collection of data
 - Chemistry Day
- Most students conduct trials at home
 - I open labs after school for about 4 weeks....students sign up for limited space
- Final project is a poster presentation accompanied by a research paper
 - Great advantage to this project - everything is graded in one day!
- Parents come to Chemistry Night to see the great work (they love it!)

Research and Innovation

- First term assignments
 - Current book or article review
 - PowerPoint to class
 - Literature Review
 - Students use online libraries to access a primary research article. Students answer a set of questions about the central problem, the research, and the analysis of data. The Journal of Emerging Investigators is an excellent source.
 - Writing an abstract
 - Students are given a scientific article for which they must write an abstract using MSSEF (MA State Science and Engineering Fair) abstract guidelines

Research and Innovation

- First term assignments, cont.
 - Relationship between Methods and Procedure
 - Students convert the Materials and Methods section of an article into a detailed protocol
 - Design and conduct a simple experiment using Vernier probes
 - Working in pairs, students must design two experiments that use three different Vernier probes. An experimental protocol must be approved by me before they begin. They are assessed by a regular lab report.

Research and Innovation

- Ongoing assignments to help students develop a project focus
 - Discussion forums on Moodle that focus on various competitions, such as Junior Science and Humanities Symposium, Boston FIRST, We Can Change the World (Siemens)
 - Biomimicry Case Studies
 - YouTube, TED talks, etc.

Research and Innovation

- First term assignments, cont.
 - Experimental design with secondary research
 - Students must conduct background research that lays the foundation for their experimental or engineering design
 - This information precedes the protocol (and ends up being the introduction to their final research paper)
 - Experimental or Engineering design is developed (might take several drafts)
 - Once approved the project may begin
 - No matter the type of project, each student must complete all MSSEF paperwork and have parents/guardians and mentors sign

Research and Innovation

- Second term assignments
 - Experimentation while keeping a notebook
 - Students follow MSSEF guidelines for a lab notebook. Entries must be signed by the student, a colleague, and finally by me on a weekly basis
 - Grant proposal
 - Just like a “real” scientist, students must write a grant to “fund” their projects. I use a link to the Foundation Center website that students use for guidance.

Research and Innovation

- Second term assignments, cont.
 - Research paper
 - Students use the JSHS (Junior Science and Humanities Symposium) guidelines
 - PowerPoint presentation
 - Students present a PowerPoint presentation or their paper and colleagues engage in peer review

Research and Innovation

- Project continuation
 - Occasionally, a student is so engaged in the research project that he/she opts to take the course for a second, third, or even fourth second. I tweak the assignments that could have benefit if repeated, but the student's primary focus is to continue with his/her research project or engage in a new project.

Research in Science

- Submission to competitions
- Submission for publication

Resources

- Junior Science and Humanities Symposium <http://www.unh.edu/nnejshs/>
- Massachusetts State Science and Engineering Fair
<http://massscifair.com/fairs/high-school/manual-forms>
- Biomimicry Institute <http://www.biomimicryinstitute.org/case-studies/>
- Ask Nature [http://www.asknature.org/article/view/what is biomimicry](http://www.asknature.org/article/view/what_is_biomimicry)
- Foundation Center
<http://foundationcenter.org/getstarted/tutorials/shortcourse/components.html>
- Journal of Emerging Investigators <http://www.emerginginvestigators.org/>
- Journal of Experimental Secondary Science
<http://www.jes2s.com/index.html>
- Siemens Foundation <http://www.siemens-foundation.org/en/>