Using the Scientific Method to teach the Framework

Feb. 15, 2017
Kelly Grossmann, STEM Librarian
Eastern Michigan University
Presenting the Problem

“I don’t know why I tested X and Y, but I need a paper that explains these results.”

“I’m only getting articles that say X, but my results say Y so I can’t use them.”

“My hypothesis is A, but these papers say B, so I won’t use any of them.”

“These [less than legitimate] sources support my hypothesis so I’ll use them.”

“I think Y, but these papers say Z. I need papers that say Y.”

[Not actual quotes]
Students left with...

Lack of sources

Frustration

Confirmation bias

‘Alternative facts’

Poor practice skills
How can we help them stand on the shoulders of giants?
Analysis of the Problem

Not asking questions

OR

Not revisiting questions

Lacking a spirit of inquiry in their research!
Analysis of the Problem

“I need papers that say high concentration of carbon dioxide increases the rate of photosynthesis”

- Finite; Inflexible;

“How does the rate of photosynthesis change with carbon dioxide concentration?”

- Open;
- Allows for reexamination and flexibility in the search;
Defining “Inquiry”

“A process that focuses on problems or questions in a discipline to extend the knowledge in that field.” - ACRL Framework

“The controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole.” - John Dewey

“A request for information.” - Merriam-Webster’s Dictionary

For today’s chat, we will be discussing how to help students to understand the practice of inquiry, instead of the instructional method of teaching by inquiry; though you could teach the practice of inquiry through inquiry-based lessons if you wish to do so.
Threshold Concept: Research as Inquiry

Research is iterative and depends upon asking increasingly complex or new questions whose answers in turn develop additional questions or lines of inquiry in any field.

Learning dispositions:

- consider research as open-ended exploration and engagement with information;
- appreciate that a question may appear to be simple but still disruptive and important to research;
- value intellectual curiosity in developing questions and learning new investigative methods;
- maintain an open mind and a critical stance;
- value persistence, adaptability, and flexibility and recognize that ambiguity can benefit the research process;

http://www.ala.org/acrl/standards/ilframework
Knowledge Practices

Learners who are developing their information literate abilities:

1. Formulate questions for research based on information gaps or on reexamination of existing, possibly conflicting, information;

2. Determine an appropriate scope of investigation; deal with complex research by breaking complex questions into simple ones, limiting the scope of investigations;

3. Use various research methods, based on need, circumstance, and type of inquiry; monitor gathered information and assess for gaps or weaknesses;

4. Organize information in meaningful ways; synthesize ideas gathered from multiple sources;

5. Draw reasonable conclusions based on the analysis and interpretation of information;

http://www.ala.org/acrl/standards/ilframework
Knowledge Practices & Scientific Method

Learners who are developing their information literate abilities:

1. Formulate questions for research based on information gaps or on reexamination of existing, possibly conflicting, information;

2. Determine an appropriate scope of investigation; deal with complex research by breaking complex questions into simple ones, limiting the scope of investigations;

3. Use various research methods, based on need, circumstance, and type of inquiry; monitor gathered information and assess for gaps or weaknesses;

4. Organize information in meaningful ways; synthesize ideas gathered from multiple sources;

5. Draw reasonable conclusions based on the analysis and interpretation of information;

1. **ASK QUESTIONS**

2. **FORMULATE HYPOTHESES, DEVELOP PREDICTIONS**

3. **EXPERIMENT, GATHER DATA**

4. **ANALYZE**

5. **DEVELOP THEORIES**

http://www.ala.org/acrl/standards/ilframework
The Scientific Method

1. Ask a Question
2. Research Existing Sources
3. Formulate a Hypothesis
4. Design and Conduct a Study
5. Draw Conclusions
6. Report Results
The Scientific Method as an Ongoing Process

1. Make Observations
   - What do I see in nature?
   - This can be from one's own experiences, thoughts, or reading.

2. Think of Interesting Questions
   - Why does that pattern occur?

3. Formulate Hypotheses
   - What are the general causes of the phenomenon I am wondering about?

4. Develop Testable Predictions
   - If my hypothesis is correct, then I expect a, b, c,....

5. Gather Data to Test Predictions
   - Relevant data can come from the literature, new observations, or formal experiments.
   - Thorough testing requires replication to verify results.

6. Refine, Alter, Expand, or Reject Hypotheses

7. Develop General Theories
   - General theories must be consistent with most or all available data and with other current theories.
Additional Threshold Concepts

Scholarship as Conversation
-- publishing information and using others’ published information plays an important role in the Scientific Method

Searching as Strategic Exploration

Authority Is Constructed and Contextual
Using STEM Concepts to Teach Information Literacy Skills in First-Year Library Classes
Sarah Morris | Instruction Librarian | Loyola University Chicago

Defining STEM
STEM, an acronym for Science, Technology, Engineering, and Math, refers to curriculum and learning that focuses on helping students acquire skills in areas such as the following:
- Creative problem-solving
- Experimentation
- Critical thinking
- Group work
- Exploration and inquiry

The core skills of STEM, such as critical thinking, intersect with the core skills of information literacy.

Defining Information Literacy
Information literacy is knowing when and why you need information, where to find it, and how to evaluate, use, and communicate it in an ethical manner.

At its core, information literacy is about finding and using information.

Teaching Principles
STEM and Information Literacy Instruction lend themselves to some shared teaching principles:
- Connected Learning - A learner-centric approach emphasizing active learning and digital tools
- Inquiry-Based Learning - A umbrella concept that connect project, product, and design-based learning activities
- Flipped classroom - Students review content outside of class and use class time for activities, discussion, and collaboration

Mapping STEM and Information Literacy Concepts
By looking at information literacy in relation to STEM concepts, we can gain new insight into what we mean by the term information literacy and communicate that insight to different audiences. STEM can provide a framework for understanding information literacy. Rather than exploring the interactions between the core concepts of STEM and information literacy can help us explore new ideas and connections to strengthen existing information literacy content.

The way we ‘do’ STEM and information literacy involves the scientific method and the research process, which can be mapped to reveal connections worth exploring.

Incorporating STEM into Information Literacy Instruction
Finding ways to connect academic research to first-year students’ everyday reality to draw upon past knowledge, and to make research interactive can appeal to different learners, and to influential leaders and can help first years begin building foundational skills.
- Scaffolding and Mapping - Since most students are familiar with the scientific method, it can be used as a scaffolding tool to introduce academic research.
- Activity - Students brainstorm steps to the research process and then map the research process to the scientific method.
- Problem-Based Learning - STEM lends itself to hands-on learning and using real-world scenarios can help students see the utility of research.
- Activity - Have students work in groups to find different types of resources for a STEM-related scenario, such as an urban planning project.
- Evaluating Popular Science Sources - Having students practice their evaluation skills with popular science articles can build critical thinking, science, and data literacy skills.
- Activity - Have students evaluate end fact-check a popular article on a divisive scientific topic, like climate change and discuss how scholarly sources are used.

Get the Online Handout
Links, resources, & sample activities:
http://bit.ly/1KHGzWw
Scientific Method (Methods of Science)

Inquiry in Education
Further reading...


Applying to Reference Consultations

1. Review the steps of the Scientific Method with the students. Visuals are handy.
2. Emphasize the question asking stage.
3. Encourage students to verbalize a question, help students to frame question of appropriate scope.
4. Help students to identify variables in their question.
5. Demo experimenting with search terms.
6. Discuss how to analyze the results.
7. Discuss how to reframe, rephrase, or readdress the question, and search again.
Scientific Method Mapped to IL Practices

- **Ask a Question**
  - Ask a Question: What do you want to investigate?
- **Formulate Hypothesis**
  - Formulate hypothesis/thesis: Identify variables, main concepts
- **Conduct Experiment**
  - Try a search, experiment with search terms
- **Analyze Results**
  - Analyze search results: How many? Do they appear relevant? Do they discuss same/similar variables? Analyze articles: What evidence do they provide that is relevant?
- **Share Conclusions**
  - Synthesize information. What evidence have you compiled? What supports your hypothesis? What does not? Do not ignore conflicting information, address it! Draw conclusions from the evidence provided in the articles
Asking the Question

A useful guide for helping students to frame their research question:

http://stem4all.edc.org/content/introduction-inquiry-learning
Advantages of Scaffolding with Scientific Method

Many students are already somewhat familiar with the Scientific Method as a process for inquiry-based research.

Something familiar and comfortable for the students, help remove some search anxiety.
Other Applications?

- As a tool for faculty buy-in
- In non-STEM disciplines
- In a classroom setting
- As a flipped classroom tool
Potential Pitfalls

Does the Scientific Method, and by extension this instructional technique, promote a misleadingly formulaic and linear view of scientific research?

With NGSS or Common Core, is the Scientific Method taught in K-12 as often or as explicitly as it once was?

Can students new to the research process approach this type of metaphor without getting too caught up in the details?

Additional pitfalls?
Discussion

Has anyone tried this approach? Positive experiences? Negative experiences/difficulties?

Does the use of the Scientific Method parallel seem helpful or limiting?

Ideas for extending this approach? Recommendations for formalizing in a group discussion?
Slide 4.
Cedalion standing on the shoulders of Orion from Blind Orion Searching for the Rising Sun by Nicolas Poussin, 1658, Oil on canvas; 46 7/8 x 72 in.

Slide 6.
Arabidopsis thaliana photograph by Charles Andrès
https://commons.wikimedia.org/wiki/File:Arabidopsis_thaliana_rosette_transparent_background.png

Slide 7-10.
http://www.ala.org/acrl/standards/ilframework
https://www.merriam-webster.com/dictionary/inquiry

Slide 11.
Lumen Learning. The Scientific Method.
https://lumen.instructure.com/courses/199939/pages/Section2-3?module_item_id=4575153
https://4thgradesteele.wikispaces.com/The+Scientific+Method
http://www.ck12.org/book/CK-12-Earth-Science-For-Middle-School/section/1.1/

Slide 12.
https://commons.wikimedia.org/wiki/File:The_Scientific_Method_as_an_Ongoing_Process.svg


https://commons.wikimedia.org/wiki/File:Question_mark_1.svg