Teaching Critical Thinking Skills in Science with *sInvestigator*

Visit http://bit.ly/sInvestigatorASTE *to download software for use during this presentation*

ASTE Workshop 2018

College of Education and Human Development

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Session Objectives

- Explore the use of *sInvestigator* as an instructional tool for the collaborative evaluation of scientific evidence
- Share assessments of students' information literacy in science education
- Share preliminary research findings from our work with a undergraduate honors class

Agenda

- Introduction to *sInvestigator*
- Installation & use of software
  - http://bit.ly/sInvestigatorASTE
- Measurement of information literacy in science contexts
- Overview of research findings to date
- Collaborative Discussion

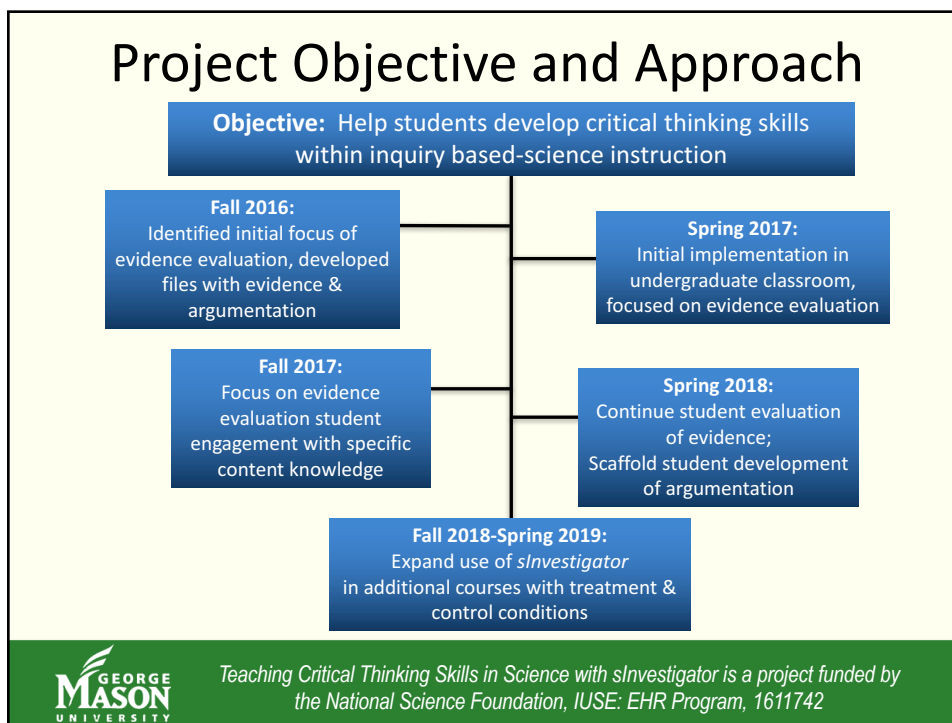# Project Objective and Approach

➢ **Objective:** Help students develop critical thinking skills within inquiry based-science instruction

➢ **Approach:** Students, working in teams, are guided through a systematic process of solving a complex problem by using the *sInvestigator* intelligent computer system
  - Generate competing hypotheses from their observations of events in nature
  - Use their hypotheses to generate new lines of inquiry and discover new evidence
  - Test their hypotheses based on the evidence they are discovering, to determine the most likely hypothesis
  - Present and debate their results

➢ **Dissemination Goal:** To all STEM disciplines, for both undergraduate and K-12 students

Project Objective and Approach

Objective: Help students develop critical thinking skills within inquiry based-science instruction

Fall 2016:
Identified initial focus of evidence evaluation, developed files with evidence & argumentation

Spring 2017:
Initial implementation in undergraduate classroom, focused on evidence evaluation

Fall 2017:
Focus on evidence evaluation student engagement with specific content knowledge

Spring 2018:
Continue student evaluation of evidence;
Scaffold student development of argumentation

Fall 2018-Spring 2019:
Expand use of *sInvestigator* in additional courses with treatment & control conditions

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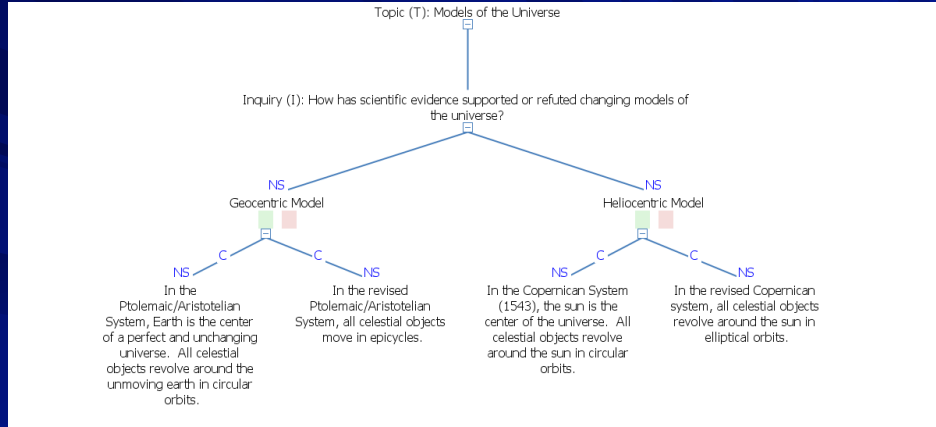# Example of how we are using *sInvestigator*

Fall 2017 – History of Science

– Undergraduate honors course

– 32 students
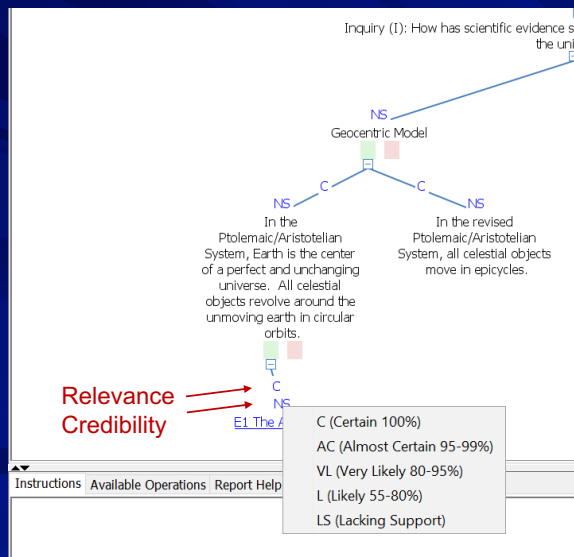
Two classroom experiences with *sInvestigator*

– Brief lectures by professor

- (Class 6) Copernican Revolution

- (Class 9) Evolution

– Collaborative groups of 3 or 4

- Initial argumentation and evidence provided by professor

- Search for additional evidence supporting or refuting the given hypotheses

What is *sInvestigator*?

Topic (T): Models of the Universe

Inquiry (I): How has scientific evidence supported or refuted changing models of the universe?

NS — Geocentric Model NS — Heliocentric Model

C — In the Ptolemaic/Aristotelian System, Earth is the center of a perfect and unchanging universe. All celestial objects revolve around the unmoving earth in circular orbits.

C — In the revised Ptolemaic/Aristotelian System, all celestial objects move in epicycles.

C — In the Copernican System (1543), the sun is the center of the universe. All celestial objects revolve around the sun in circular orbits.

C — In the revised Copernican system, all celestial objects revolve around the sun in elliptical orbits.

Teacher or students develop a series of hypotheses and sub-hypotheses to conduct a scientific inquiry

What is sInvestigator?

Inquiry (I): How has scientific evidence su... the univ...

NS — Geocentric Model

C — In the Ptolemaic/Aristotelian System, Earth is the center of a perfect and unchanging universe. All celestial objects revolve around the unmoving earth in circular orbits.

C — In the revised Ptolemaic/Aristotelian System, all celestial objects move in epicycles.

Relevance
Credibility

C
NS
E1 The A

C (Certain 100%)
AC (Almost Certain 95-99%)
VL (Very Likely 80-95%)
L (Likely 55-80%)
LS (Lacking Support)

Instructions | Available Operations | Report Help

Students assign items of evidence to hypotheses and evaluate relevance and credibility

What is sInvestigator?
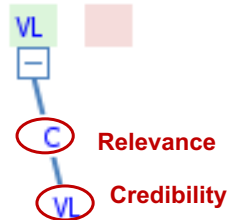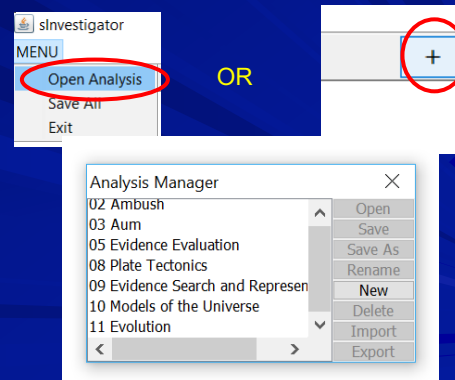

sInvestigator calculates the likelihood that hypotheses are true based upon assigned evidence and ratings

Exploring sInvestigator
Studying Models of the Universe

1. Launch sInvestigator.
2. Click on the PLUS SIGN to open the Analysis Manager.
3. Select **10 Models of the Universe**.

Attach items of evidence to the initial argumentation

Click to show items of evidence

Attach items of evidence to the initial argumentation

Double click on the item of evidence for brief description and URL

Example - E1 (The Almagest)

➤ As you drag the evidence toward the hypothesis, two squares are displayed, a green one (for favoring evidence), and a red one (for disfavoring evidence).

➤ Drop the text on the corresponding square.

➤ The evidence is now associated with the hypothesis.

Example - E1 (The Almagest)

Assume that the **relevance** of this evidence is certain.

Evaluate its **credibility.**

What is the probability that what the evidence is telling us is true?

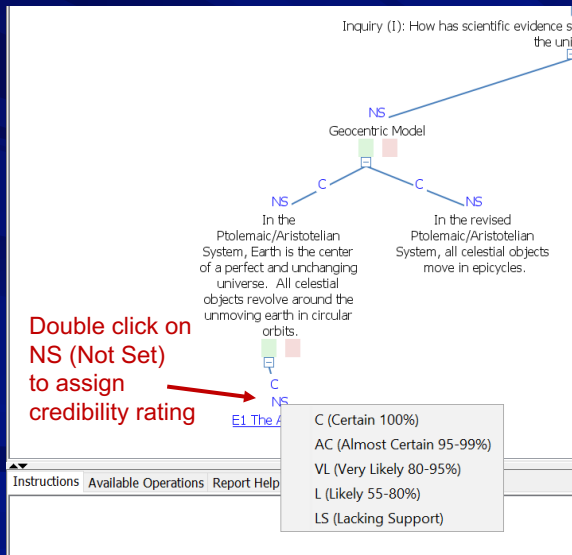*Right-click on the item of evidence and select "Analyze."*

Example - E1 – The Almagest
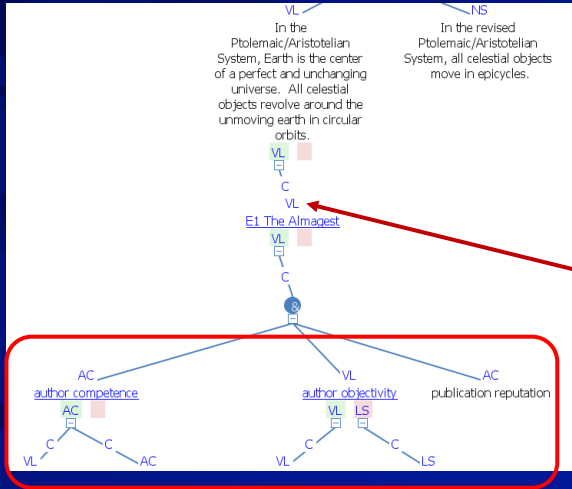
1. Evaluate author competence

2. Evaluate author objectivity

3. Evaluate publisher reputation

The combined ratings determine the overall credibility of the item of evidence.

Example - E1 – The Almagest

Students can evaluate credibility directly without rating author and publisher information.

Double click on NS (Not Set) to assign credibility rating

C (Certain 100%)
AC (Almost Certain 95-99%)
VL (Very Likely 80-95%)
L (Likely 55-80%)
LS (Lacking Support)

8

Other ways *sInvestigator* is used
1. **Find items of evidence and attach to argumentation**
2. **Modify argumentation based on evidence**
3. **Justify ratings of evidence.**

Using *sInvestigator*
in Inquiry-based Instruction

– How much of the argumentation should the teacher provide for the students?

– How much evidence should teachers provide to students?

– How should teachers expect students to justify their ratings?

Research Questions

- How do students use *sInvestigator* as they identify and evaluate relevant evidence for a given hypothesis?

- In what ways do students evaluate academic sources differently after using sInvestigator?

- Are students learning content in an inquiry setting?

- What are the benefits and challenges of using *sInvestigator* as an instructional strategy in an undergraduate science course?

Measures

- Pre & post measures
  - *Evaluation of Scientific Evidence (Current Topics)*
  - *Content Knowledge (Historical Topics)*
- Electronic class "exit tickets"
  - *Ranking credibility of familiar evidence*
- Assessing credibility of evidence examined during class
- Observations of students during classes
- Group audio recordings & video recordings of class

Evaluating Scientific Evidence
### *Topic of Current Interest*

- This measure was developed by the team for use throughout the project
  - How do student evaluate credibility and relevance of three online scientific evidence?
  - Administered at beginning and end of semester
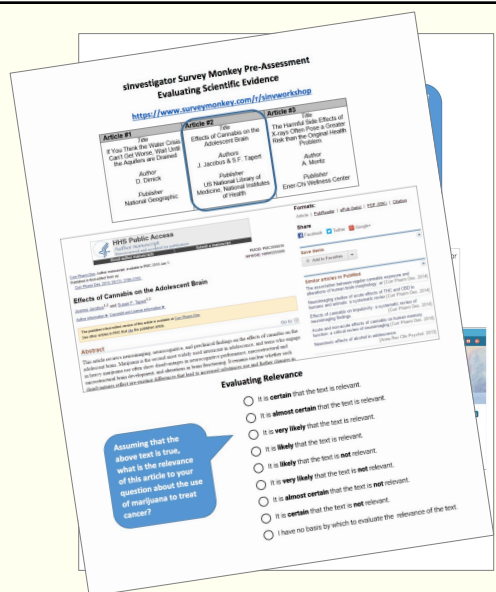
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Evaluating Scientific Evidence
Historical Topics

- Students completed an online exit ticket based on evidence they had evaluated using sInvestigator during class
  - Categorized items of evidence as most or least credible
  - Ranked 8 items of evidence by credibility
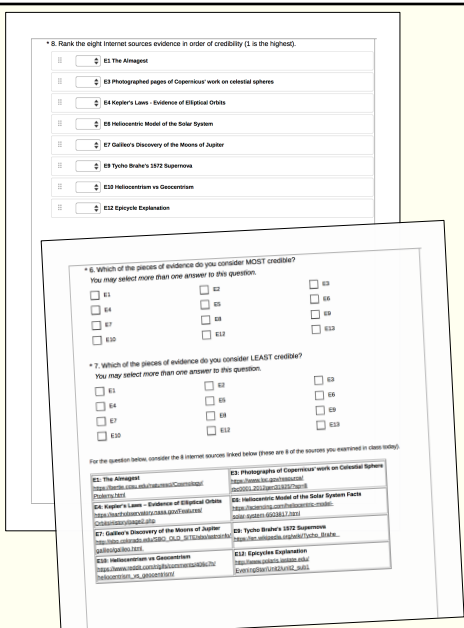
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Preliminary Findings
Ranking Credibility of 8 Items of Historical Evidence
<u>**Copernican Revolution**</u>

- *Student ranking of two primary (original) sources*
  - **Only 13 of 27 students ranked photos of Copernicus' work in Library of Congress as highly credible (e.g. rank of 1 or 2)**
    (but 27 of 28 students ranked them within top 4 of 8 sources)
  - **18 of 27 students ranked "The Almagest" as highly credible**
    (but 24 of 27 students ranked them within top 4 of 8 sources)
- *Student ranking of two unreliable sources*
  - **25 of 27 students ranked the Wikipedia entry as unreliable or least credible (e.g. rank of 7 or 8 out of 8)**
    (The other students assigned a rank of 6)
  - **21 of 27 students ranked the Reddit thread a 7 or 8 out of 8**
    (5 of the remaining students assigned it a rank of 6)

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Preliminary Findings
Ranking Credibility of 8 Items of Historical Evidence
Copernican Revolution

- *Highest Mean Ranking*
  - **NASA Earth Observatory (.gov website)**
    - Logo displayed prominently at top of page

- *Conclusions*
  - *Many students did not trust the text or photos of primary sources published online; students may be more inclined to trust new information or familiar sources*
  - *Almost all students appropriately identified the Reddit and Wikipedia sites as having low credibility*
  - *The mean ratings of the two educational institution websites were equal and exceeded only by the ratings of the two primary sources and the governmental website*

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Preliminary Findings
Ranking Credibility of 8 Items of Historical Evidence
<u>Evolution</u>

- *Most reliable sources*
  - **21 of 26 students ranked educational institution website as highly credible**
    - *25 of 26 students ranked it in top 4*
  - **Only 13 of 26 students ranked peer-reviewed journal article as highly credible****
    - *Mean rating same as tutorial on pbs.org website*
- *Least reliable sources*
  - **20 of 26 students ranked the Wikipedia entry as 7 or 8**
    (The other students assigned a rank of 6)
  - **23 of 26 students ranked the Reddit thread as 7 or 8**

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Preliminary Findings
Ranking Credibility of 8 Items of Historical Evidence
Evolution

- *Highest Mean Ranking*
  - **PBS Library (.org website)**

- *Conclusions*
  - *Students rated magazines (Science and New Yorker) more highly than a science blog*
  - *Almost all students appropriately identified the Reddit and Wikipedia sites as having low credibility*
  - *Students rated the pbs.org science tutorial as being more credible than a peer-referenced journal article*

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Preliminary Findings –Topics of Current Interest
Student Evaluation of sources
Current sources

- *Students were asked to select one of three current sources that they would most likely use as a reference*
- *Pretest:*
  - *Consumer Reports, British Institute of Radiology, The EnerChi Wellness Center*
  - *25 of 27 students selected British Institute of Radiology*
- *Posttest:*
  - *The Sports Journal, International Journal of Sports Nutrition, TeamSnap*
  - *21 of 28 students selected the International Journal of Sports Nutrition*
- *Implications – The majority of students selected the most credible journal in a more nuanced list*
- *Limitations – This study was conducted with honors undergraduate students*

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Content Measures

- **There was a statistically significant increase in students' scores on the Copernican Revolution content measure**
  (Pre M=5.50, SD=2.57; post M=8.96, SD=1.31), t(25)=-6.88, p <.001)
  - *Post test data – negatively skewed (did not meet assumption of normality)*
  - *Non-parametric methods (Wilcoxon signed rank test) were considered but did not meet assumption of symmetry of results above and below mean*
  - *25 of 26 students improved their scores*
- **There was a statistically significant increase in students' scores on the Evolution content measure**
  (Pre M=6.34, SD=1.58; post M=8.30, SD=1.31), t(23)=-5.51, p < .001)
  - *20 of 24 students improved their scores*
- **Conclusions and Limitations:**
  - *Students who use sInvestigator to assign evidence to hypotheses and to rate credibility of sources learn scientific content*
  - *Undergraduate honors students were highly engaged with sInvestigator*

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Preliminary qualitative findings

- Use of *sInvestigator* in small groups promoted collaborative conversations and debate
- Students were engaged in discussion about science content while working in groups
  - *Although some time was spent off task, while using sInvestigator students regularly returned to discussion of content*
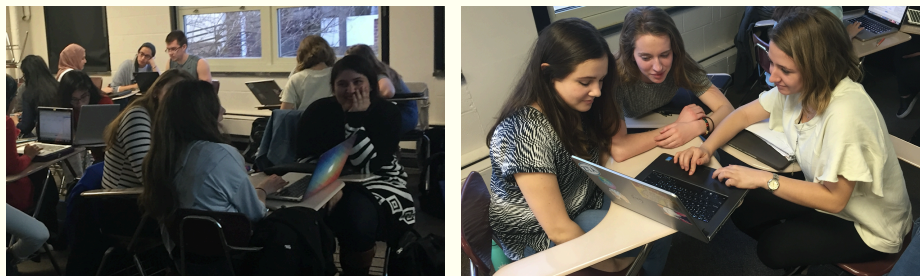
Students voices on using sInvestigator as an Inquiry tool

"Collaboration is key!"

"It forced me to read up on articles related to course topics which sort of indirectly immerses you into the topic."

"I now relate to science in terms of credibility, whether facts are backed up with a credible source or not."

"I feel like it deepened our knowledge but added a lot of extra work."

Additional Findings

- Students are tech-savvy and require purposeful scaffolding rather than direct step-by-step instruction
  - *"They were surprisingly good at picking up the different operations of the the tools" - Graduate Assistant*
- The software scaffolds and supports student thinking. Students relied on the *sInvestigator* guide that was added to the system to support evaluation of credibility of an article
  - *This new feature of sInvestigator was added to support the lesson introducing Evidence Evaluation, but students continued to use it throughout the semester*

Conclusions, Limitations, Implications

- The software team added important functionality to the sInvestigator tool during the first 18 months of our project, especially the Evidence Features Evaluation assistant. Additional refinement of the tool will continue.
- Student gains in content knowledge are reassuring, especially for instructors who are transitioning to student-centered instruction
- We have not yet tested the sInvestigator system with students as they develop their own argumentation. This will occur in Spring 2018.
- Year 3 will include implementation in a non-honors class, as well as in a quasi-experimental controlled study