Socio-Scientific Issues

- **Socio-Scientific Issues (SSI):** Socio-scientific issues are complex, open-ended issues that embed science content and practices within the social issues in which they occur.

- SSI instruction contextualizes science learning within societal issues and provides an opportunity for students to learn science in the same fashion as it occurs in their lived experiences.

- Zeidler, 2014; Sadler, 2011

- Resources available at ri2.missouri.edu
Rationale for Issue-Based Teaching

- Education should help prepare students to engage with issues, problems, and choices that matter in their lives. Many of these issues have important connections to science; it is the role of science education to help students engage with these issues.

- These issues are informed by science but their solutions are underdetermined by science.

- Attempting to separate the science of these issues from the societal concerns and implications limits the educational value of dealing with the issues in the first place.
Rationale for Issue-Based Teaching

- Science teachers are understandably concerned with losing time/focus on science content.
- Research shows SSI teaching can result in gains in student learning of:
  - Science Content (Klosterman & Sadler 2010; Herman, 2014; Sadler, Romine, & Topcu, 2016)
  - Nature of Science (Khishfe & Lederman, 2006; Eastwood, Sadler, Zeidler, & Applebaum, 2012; Herman, 2017)
  - Informal and Formal reasoning strategies (Sadler, Barab, & Scott, 2007; Zeidler, Herman, Ruzek, & Linder, 2013; Kinslow, Sadler, & Nguyen, 2018).
- In addition to offering an engaging and effective way to learn science, SSI instruction is aligned with several international standards documents (EACEA, 2011; NRC, 2013; ESERA, 2015; ACARA, 2016).
- Ultimately, we fail our students if we focus on teaching “school science” out of context with the social issues in which science occurs.
Key aspects of SSI teaching

- The issue should be a highlighted, focal aspect of teaching & learning - NOT a tangential, de-emphasized or minimal aspect.
- Students should explore and develop understandings of the scientific phenomenon through scientific practices (e.g., Modeling) - NOT memorize terms or simple procedures.
- Students should synthesize their learning and elucidate their own position or solution. - NOT decontextualized learning.
- Students should explore the larger system dynamics surrounding an issue. - NOT decontextualized learning.
- Students should have the opportunity to practice and gain Socio-Scientific Reasoning (SSR). - NOT simply regurgitating facts, but rather critically thinking and reasoning with their science knowledge.
Socio-Scientific Reasoning

Socio-Scientific Reasoning (SSR) is a set of interrelated competencies that describe the complex thinking and reasoning needed for students to make sense of science in the context of complex issues (Sadler, Barab, & Scott, 2007).

Cognitive mechanisms for sense making and understanding SSI – room also for more cogs in the machine.

Five SSR competencies.
1. Examining the social and scientific areas of complexity for an SSI.
2. Appreciation and empathy for the multiple stakeholder perspectives around an SSI.
3. Exploring areas of the SSI in need of further inquiry.
4. Recognizing the affordances and limitations of science offers for understanding SSIs.
5. Using reflective scientific skepticism to critically examining an SSI for potential bias.
Complexity

- The *complexity* competency pertains to a student’s ability to recognize that an SSI is complex from social and scientific perspectives beyond simply examining cause and effect relationships.

- Students demonstrate growth in the complexity domain when they move from cause/effect mechanisms to reflective thinking in which students evaluate complex, often conflicting forms of information around the scientific and social components of an issue.
Inquiry

- Scientific endeavors and socio-scientific issues by their nature are always subject to further *inquiry* and refinement of our understandings.

- Students exhibiting naïve inquiry practice may only be able to list areas of uncertainty around an issue. Advanced inquiry practice involves identifying specific questions for further inquiry and describing a plan to examine those questions from social and scientific dimensions of the issue.
Perspective taking

- The competency of perspective-taking involves more than simply identifying different stakeholder opinions on an issue.

- Sophisticated perspective-taking SSR involves the ability to analyze the problems and potential solutions for an issue from diverse viewpoints including challenging one’s own perspective on the issue.
Affordances & Limitations of Science

- Science provides certain *affordances* for understanding and resolving complex SSIs; that is, science offers important insights into the resolution of these issues.

- SSIs cannot be solved, however, exclusively by considering the science.

- Students should understand the *limits* of what science can address.

- For example, science can describe how the climate is changing, factors contributing to these changes, and models for what will likely happen given different courses of action; however, science cannot explain how society weighs political priorities, economic implications, and ethical considerations.
Reflective Scientific Skepticism

- Goal is not the denial of evidence, doubting all facts, or doubting the ability to know. We are not promoting a pedagogy that turns students into jaded skeptics doubting everything they hear.

- Misuse of ‘skepticism’ in mass media.

- Reflective Scientific Skepticism – Specific nomenclature in order to call out the social and scientific connections for the complex socio-scientific issues students must navigate in order to develop functional scientific literacy and to avoid confusion with the misuse of ‘skepticism’ in mass media.

- 2 focal areas to help students develop Reflective Scientific Skepticism
  - The Generation of Science Knowledge (Nature of Science)
  - Science Communication (Science Media and Information Literacy)

- This takes practice and can be supported with instructional tools.

- [http://ri2.missouri.edu/content/Instructional-Tools](http://ri2.missouri.edu/content/Instructional-Tools)
Questions so far?
QuASSR

- Quantitative Assessment of Socio-Scientific Reasoning
- First developed and validated by Romine, Sadler, & Kinslow (2017)
- Scenario based assessment of SSR
  - SSI Vignette followed by a series of questions designed to elicit SSR
- Early versions - open-ended hand-written requiring elaborate and time-consuming scoring
- Romine & colleagues, 2017 – ordered multiple choice scored through Qualtrics
- Latest efforts focused on open-ended responses provided through Qualtrics with detailed scoring rubrics.
QuASSR Scenarios

Iterative process. Early versions

There are over 300 known species of mosquito worldwide, some of which spread diseases to humans. Mosquitoes spread diseases by injecting saliva while drinking blood from humans. Mosquitoes are also vectors for viral and bacterial diseases.

During late 2015, the Zika virus first emerged in a major global outbreak spread by mosquitoes. While the symptoms of mosquito-borne diseases vary, they are generally mild for the majority of people. In contrast, pregnant women and newborns are at higher risk for more severe symptoms.

Scientists at the Des Moines Water Works, the region's water supply, are responsible for ensuring the water is safe to drink. Recent tests of the water quality, performed by Iowa State laboratories and the Environmental Protection Agency (EPA), indicate that the water meets all federal and state standards.
https://missouri.qualtrics.com/jfe/form/SV_9TuRx18eNRLtuPX
QuASSR analysis

- Sample Open-ended data via Qualtrics
- Sample Open-ended data processed for scoring
Romine and colleagues (2017) used the QuASSR with a large undergraduate science audience.

2 Scenarios (Branville Bay & Pavillion Fracking)

Ordered multiple choice questions compiled via Qualtrics and analyzed statistically.

3-level ordinal partial credit model (0=low SSR, 1=moderate, 2=high)

Based on 4 competency SSR as described by Sadler, Barab, & Scott, 2007 (complexity, inquiry, perspectives, skepticism)

Romine measured pre/post gains based on marginal means derived from two-level linear pattern mixture models implemented in SAS (Hedeker & Gibbons, 1997).

Employed Generalizability (G-theory) and Rasch modeling with the analysis to examine instrument validity.

Key findings:

Acceptable fit of items with the Rasch partial credit model demonstrates construct validity of items (Table 3). Infit and outfit indices fall in the range of 0.80–1.24 and 0.74–1.33, respectively. These indicate that items have appropriate construct validity for use in low-stakes testing situations.

Rasch analysis suggests that the four dimensions of SSR: Complexity, perspectives, inquiry, and skepticism, are representative of a single construct.

Analysis of test variance indicates that variation across scenarios was negligible in comparison to the variance across students and items.

Adding a second scenario leads to a marked improvement in test reliability. Adding a third scenario would lead to measurement reliability approaching 0.85. However, adding more scenarios (beyond three) would be a case of diminishing returns given the time it takes for students to respond to a scenario.


QuASSR analysis

- Kinslow (2018) & (in review) used the QuASSR with high school science classes taught with an SSI approach over 8 and 16 week semesters.
- Open ended responses recorded via Qualtrics
- 2 scenarios – GMOsquito & Racoon River
- 2018 used a 3-level ordinal partial credit model (0=low SSR, 1=moderate, 2=high)
- Latest study in review used a 5-level ordinal partial credit model (0=low SSR to 4=high SSR)
- Collaborated with other researchers to develop holistic scoring guides to score the results.
- QuASSR used as part of a multiple-method approach. Triangulated QuASSR results with student work samples, & interview data.
<table>
<thead>
<tr>
<th>Level</th>
<th>Complexity</th>
<th>Sample Quote/s</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>Suggests that the issue is not complex or provides an illogical response.</td>
<td>This is not a difficult situation to resolve because the scientists found a cure before so just think again. Yes, this is a difficult situation to resolve, because I don’t know what I’m doing. I don’t know how it works or what it really does.</td>
</tr>
<tr>
<td>1</td>
<td>Identifies at least one source of complexity.</td>
<td>Yes, it’s a disease that affects pregnant women.</td>
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<tr>
<td>2</td>
<td>Identifies at least one source of complexity and provides a contextual explanation or justification for one of those sources</td>
<td>Decision if the benefit of genetically modified animals being introduced outweighs the risk to ecosystems. The risks include introducing the genetically modified mosquito to birds and insects that eat them. The benefit is stopping the reproduction of the mosquito that carries the zika virus.</td>
</tr>
<tr>
<td>3</td>
<td>Identifies at least two sources of complexity and provides a contextual explanation or justification for one of those sources</td>
<td>Firstly, scientists have fought against a spread of genetic disease which could potentially destroy a portion of the human population. Finding a solution to this alone is quite tricky. Secondly, they have to worry about the environmental risk and how their solution could impact other species. If their solution were to wipe out the mosquito population how would it affect other organisms in the ecosystem? Lastly, the scientists have to worry about environmental groups and the concerns of the citizens. So, finding a solution for this particular problem is quite hard.</td>
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<tr>
<td>4</td>
<td>Identifies two or more sources of complexity and provides contextual explanations or justifications for at least two of those sources</td>
<td>This is a complicated issue because often what is best for people might not be best for the environment. On the positive side: The engineered mosquito might be a great way to protect people since there is no vaccine for the zika virus and it can cause serious issues for unborn babies. The field trials show a 90% reduction in the mosquito in the areas that the engineered males have been released. On the negative side: 1) Field trials cannot ever really model what will happen when the larger scale release occurs. Models, although good, are still limited as predictors especially when the models involve animals and animals systems. 2) The engineered mosquitoes have a new gene. The effects of this new gene over several generations are unknown. The gene product could have unknown effects on the mosquito population itself, the organisms that eat these mosquitoes, or, on other organisms that come in to contact with the mosquitoes either directly (contact) or indirectly (food chain). 3) The Keys are a major tourist area and if the wildlife is affected it could impact many aspects of the economy of the area. 4) However, if zika is not addressed in some way, this could also reduce the tourism economy generated as people decide to travel to places better protected from the zika virus.</td>
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QuASSR Analysis

Key findings from Kinslow (2018, & in review):

- Gains in SSR competencies over a long-duration intervention
- Skepticism particularly vexing – reorganized around science media literacy & nature of science
- Gains in SSR require time and a purposeful instructional approach.

Take home message: Design your analysis in accordance with your end goals.

Criticism of the QuASSR

- Some researchers have been critical of the QuASSR as an oversimplification (Ruppert, Bartlett, Perieira, Hankins, & Infante, 2018)
- This frankly is true of any assessment. The QuASSR has depth and breadth limitations. Multiple methods & larger sample sizes help to overcome.

- We must start somewhere, and the QuASSR is a good tool for researchers and teachers alike to examine the critical thinking skills necessary to solve the complex SSIs society faces.
Further Information

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SSR for research:

SSR for teaching: