Socio-Scientific Reasoning and the QuASSR

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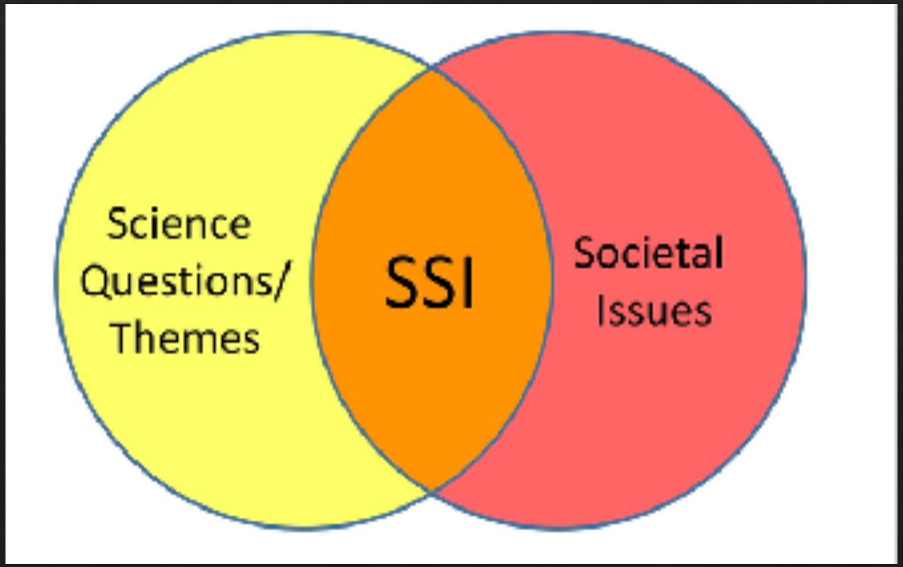
Socio-Scientific Issues

- 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)
  - Argumentation and Modeling (Zohar & Nemet 2002, Dawson & Venville, 2010; Zangori, Peel, Kinslow, Friedrichsen, & Sadler, 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

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

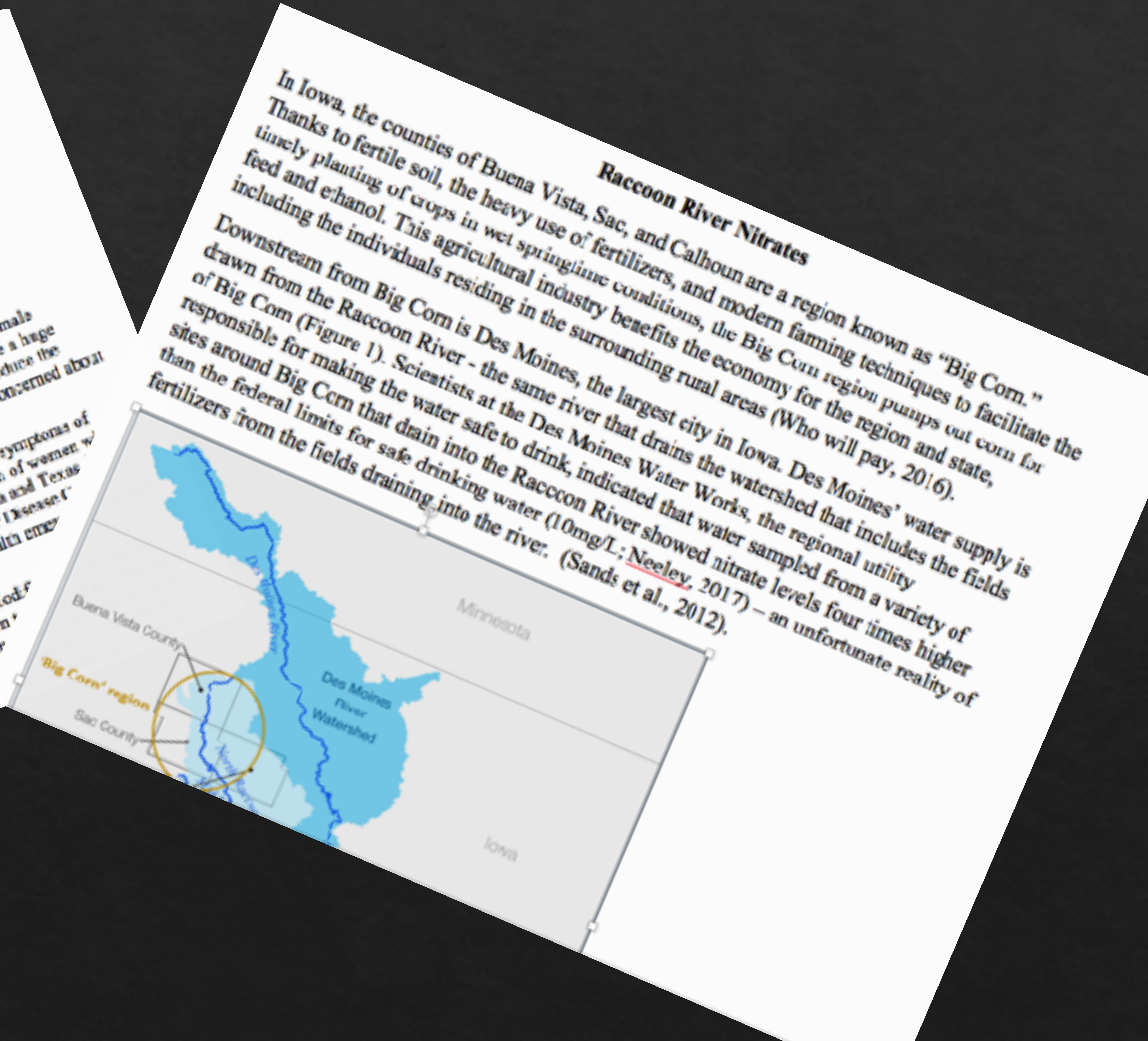
Iterative process. Early versions


GMOsquitos

There are over 3500 known species of mosquitos worldwide, some which spread disease to humans when the female mosquito draws blood from a bite and transfers microscopic disease causing organisms. Mosquito-spread diseases create a huge medical and financial impact on people worldwide. Traditionally, insecticides have been used to kill mosquitoes and reduce the transmission of disease. However, mosquitos are developing resistance to common insecticides, and people are also concerned about the safety of insecticide use for humans and the environment.

During late 2015, the Zika virus first emerged in a major global outbreak spread by mosquitos. While the symptoms of infection are generally mild for adults, Zika has been linked to miscarriage and major birth defects for the children of women infected during pregnancy. The virus has spread rapidly through South America, and recently appeared in Florida and Texas expected to spread throughout the United States anywhere mosquitos are present. Officials from the Centers for Disease C (CDC) and the World Health Organization (WHO) have declared this Zika outbreak an international public health eme is no vaccine currently available.

Oxitech is a biotech company that has developed a new technology to fight mosquitos: Genetic Modi Oxitech have successfully modified the genetic code of the Aedes mosquito, the species of mosquito known interrupts the mosquito lifecycle. In a lab, male mosquitos are engineered with the modified gene and then mate with females. The offspring that inherit the engineered gene die before they can reproduce. Oxite in mosquito infested areas and report greater than 90% reduction in Aedes mosquitos with each test.


Raccoon River Nitrates

In Iowa, the counties of Buena Vista, Sac, and Calhoun are a region known as "Big Corn." Thanks to fertile soil, the heavy use of fertilizers, and modern farming techniques to facilitate the timely planting of crops in wet springtime conditions, the Big Corn region pumps out corn for feed and ethanol. This agricultural industry benefits the economy for the region and state, including the individuals residing in the surrounding rural areas (Who will pay, 2016).

Downstream from Big Corn is Des Moines, the largest city in Iowa. Des Moines' water supply is drawn from the Raccoon River - the same river that drains the watershed that includes the fields of Big Corn (Figure 1). Scientists at the Des Moines Water Works, the regional utility responsible for making the water safe to drink, indicated that water sampled from a variety of sites around Big Corn that drain into the Raccoon River showed nitrate levels four times higher than the federal limits for safe drinking water (10mg/L; Neeley, 2017) – an unfortunate reality of fertilizers from the fields draining into the river. (Sands et al., 2012).

- https://missouri.qualtrics.com/jfe/form/SV_9TuRx18eNRLtuPX

QuASSR analysis

- Sample Open-ended data via Qualtrics
- Sample Open-ended data processed for scoring

QuASSR analysis

- 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 2: Complexity Scoring Rubric

Level	Complexity	Sample Quote/s
0	Suggests that the issue is not complex or provides an illogical response.	This is not a difficult situation to resolve because the scientists found a cure before so just find one 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
1	Identifies at least one source of complexity.	Yes, its a disease that effects pregnant woman. Yes.It will be difficult because it is a species that are all over the world. We can not get to every single mosquito in the world. So it would be hard (restatement in red)
2	Identifies at least one source of complexity and provides a contextual explanation or justification of a source	Deciding 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.
3	Identifies at least two sources of complexity and provides a contextual explanation or justification for one of those sources	Firstly, scientist have fight against a strand of genetic disease which could potentially destroy a portion of the human population. Finding a solution to this alone is quite finicky. Secondly, they have to worry about the environmental recoil and how their solution could impact other species e.g., if their solution were to wipe out the mosquito population how would it affect other organisms in the ecosystem. Or if their solution creates a new strand of virus for the mosquitoes which causes a collapse of the ecosystem. Thirdly, they have to worry about how their "cure" affects humans. Fourthly, the scientist have to worry about environmental groups and the concern of the citizens. So finding a solution for this particular problem is quite hard.
4	Identifies two or more sources of complexity and provides contextual explanations or justifications for at least two of these sources.	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 mosquitos 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 mosquitos in the areas that the engineered males have been released.On the negative side: 1) Field trials can not 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 mosquitos, 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 protect from the zika virus

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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- Andrew Kinslow, Ph.D. akinslow@cpsk12.org

SSR for research:

- Romine, W. L., Sadler, T. D., & Kinslow, A. T. (2017). Assessment of scientific literacy: Development and validation of the quantitative assessment of socio–scientific reasoning (quassr). *Journal of Research in Science Teaching, 54*(2), 274-295.
- Kinslow, A. T., Sadler, T. D., & Nguyen, H. T. (2018). Socio-scientific reasoning and environmental literacy in a field-based ecology class. *Environmental Education Research*, 1-23.

- SSR for teaching:

  - Kinslow, A., Sadler, T., Friedrichsen, P., Zangori, L., Peel, A., & Graham, K. (2017). From Global to Local: Connecting global climate change to a local ecosystem using a socio-scientific issue approach. *The Science Teacher, 84*(7), 39-46.
  - Kinslow, A.T., Sadler, T.D. (2018). Making science relevant: Using socio-scientific issues to foster critical thinking. *The Science Teacher, 85*(6).