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Constructive Science Engagement in Civic Life Using v-AIR Pedagogical Model - Toward a Useful Scientific Literacy

Human societies face a range of social and environmental problems, and overcoming these problems requires a citizenry capable of engagement with a constructive civic discourse. Science education researchers have created a variety of pedagogical models to teach science through socio-scientific Issues (SSI) (e.g., sustainability planning, meat consumption, genetic engineering), integrating ethics and moral reasoning with traditional classroom teaching. I have worked for the past 3 years on a research project seeking to better characterize constructive socio-scientific reasoning (SSR) and develop an improved pedagogical model for SSI instruction. In this research, instead of analyzing the level of engagement of students directly, we work with people in their daily lives. Using interviews with 14 citizens actively engaged in a local sustainability issue we used Grounded Theory to develop a cognitive SSR framework that integrates earlier models of epistemology, metacognition, and science engagement. The infrastructure plan was multifaceted, attempting to include design elements that would appeal to various stakeholders and use 'green' infrastructure to deliver urban 'ecosystem services'. Our SSR framework is based on a framework for Epistemic Cognition that has three main categories that were used as the basis for our coding scheme: the Aims or goals of thinking or action, Ideals about the qualities and alignment of 'good information', and Reasoning Practices that are used to drive perspective taking and standardization of ideals used in reasoning (v-AIR SSR). These three categories were used as general frames for coding the socio scientific reasoning of people. Specifically, we borrowed the virtue epistemology theory by characterizing virtuous versions of different reasoning practices, which we called v-MERPs (virtuous Meta Epistemic Reasoning Practices). Some of the key features are ethical perspective-taking, developing arguments that strengthen/support an aim, and personal meaning. By stitching together the reasoning of individuals, we constructed a model of constructive epistemic thinking that educators can use to scaffold learning to meet civic challenges in the world outside school. Further research is being done to evaluate the role of conceptual knowledge in this reasoning.

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Abstract

Human societies face a range of social and environmental problems, and overcoming these problems requires a citizenry capable of engagement with a constructive civic discourse. Science education researchers have created a variety of pedagogical models to teach science through socio-scientific Issues (SSI) (e.g., sustainability planning, meat consumption, genetic engineering), integrating ethics and moral reasoning with traditional classroom teaching. I have worked for the past 3 years on a research project seeking to better characterize constructive socio-scientific reasoning (SSR) and develop an improved pedagogical model for SSI instruction. In this research, instead of analyzing the level of engagement of students directly, we work with people in their daily lives. Using interviews with 14 citizens actively engaged in a local sustainability issue we used Grounded Theory to develop a cognitive SSR framework that integrates earlier models of epistemology, metacognition, and science engagement. The infrastructure plan was multifaceted, attempting to include design elements that would appeal to various stakeholders and use 'green' infrastructure to deliver urban 'ecosystem services'. Our SSR framework is based on a framework for Epistemic Cognition that has three main categories that were used as the basis for our coding scheme: the Aims or goals of thinking or action, Ideals about the qualities and alignment of 'good information', and Reasoning Practices that are used to drive perspective taking and standardization of ideals used in reasoning (v-AIR SSR). These three categories were used as general frames for coding the socio scientific reasoning of people. Specifically, we borrowed the virtue epistemology theory by characterizing virtuous versions of different reasoning practices, which we called v-MERPs (virtuous Meta Epistemic Reasoning Practices). Some of the key features are ethical perspective-taking, developing arguments that strengthen/support an aim, and personal meaning. By stitching together the reasoning of individuals, we constructed a model of constructive epistemic thinking that educators can use to scaffold learning to meet civic challenges in the world outside school. Further research is being done to evaluate the role of conceptual knowledge in this reasoning.

Theoretical Framework

The term 'scientific literacy' has been used in various ways in the history of science education (Feinstein, 2010; Jenkins, 1990; Laugksch, 2000; Roberts, 2007; etc.). Many definitions regard what scientific information individuals should know (i.e. Durant, 1993). In many cases, these definitions focus on the canons of traditional scientific disciplines, that is the methods, epistemology, and products of these disciplines (Roberts, 2007). In contrast, some definitions discuss scientific literacy as a situated practice in which expertise is distributed and that scientific literacy emerges as a function of collective group activity (e.g. Roth & Lee, 2002). A third class of definitions highlight the importance of science to everyday personal decisions (e.g. Anderson, 2010; NRC, 2011).

Research Questions

- *How can personal aims be characterized epistemically as it relates to engagement with science in the context of sustainability?*
- *What are the roles of these aims in constructive engagement with science in the context of sustainability?*

Methods

- Interviews to 14 citizens active in the public forum proposing a landscape.
- Code for Aims, Non-Epistemic Aims, Meta-Epistemic Aims and Ideals
- All two authors coded the entire data set

Instrument

Phenomenological coding is being used to identify epistemic and non-epistemic aims in interview transcripts (Moustakas, 1994). Early results indicate that there is a hierarchical structure to epistemic aims; that is, there both cognitive and metacognitive level epistemic aims that drive engagement.
To analyze the role of these different aims in constructive engagement, interviews are being analyzed to identify qualitatively different types of engagement. This analysis is based on the degree of questioning that the participant engages in as well as the open-endedness of their engagement. To code this analysis, we are integrating ideas from research on the constructiveness of discussions (Morin, et al., 2017), sophistication in conceptual reasoning (eg., Ruppert, Duncan, & Chinn, 2017; Zangori, et al., 2017), and argumentation (eg., Shea, et al., 2015). This affords assignment of a "level" related to the constructiveness of an individual's engagement and comparison to aim. All coding has been developed iteratively to ensure internal validity and is being coded by multiple individuals to ensure reliability.

Coding Scheme

Table 1 ***Aims***

Epistemic	
Knowledge About	
Components	Examples
Knowledge about "Design" of built environment	"I would need to see maps and data. You know how effective are these engineered wetlands at protecting or absorbing storm surge…"
Knowledge about thinking and knowledge (epistemic questions)	"...if the larger ecology of the … River is being disrupted by … larger processes like … Anthropogenic … sea level ... how do those benefits change over time or those values change over time?
What exists or happened (ontic questions)	OK [town] is very different in a few ways…The Netherlands has massive expanses of land you know that are low and that they allow to flood and we don't really have that and that's the potential problem comparing…
Knowledge For	
Components	Description
Explanation	A form that provides a description of context, process, or features.
Scenarios	A form that is used to situate a design or decision in a possible future that rests on a set of parameters.
Probability	Anything related to how likely is an event is to occur. Could be looped into scenarios but not always.
Argument	Can be for and against or for or against.
Understanding	A form that seeks basic information (e.g., I'd like to know more).
Non-Epistemic	
Green / Sustainable, Biodiversity, Cleanliness, Density Issues, Education, Beauty (space for appearance), Recreation (space for use), Safety, Cost-effective	

Table 2 - ***Ideals****, Epistemic*

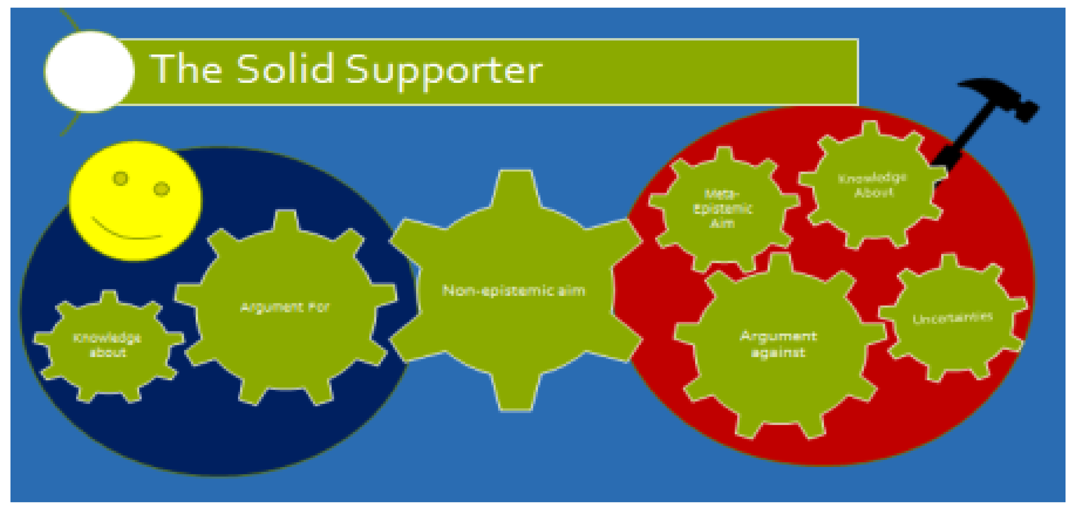
Quality	
Simple, Integrative, Inclusive-Complex, Universal, Truthful-Lacking Uncertainty, Parsimonius-Simple-Wise, Mechanistic	
Alignment	
Majority View	Specific Situation
Local Community View	Self-interest
Prior personal Experiences	Science, Science conventions, Experts

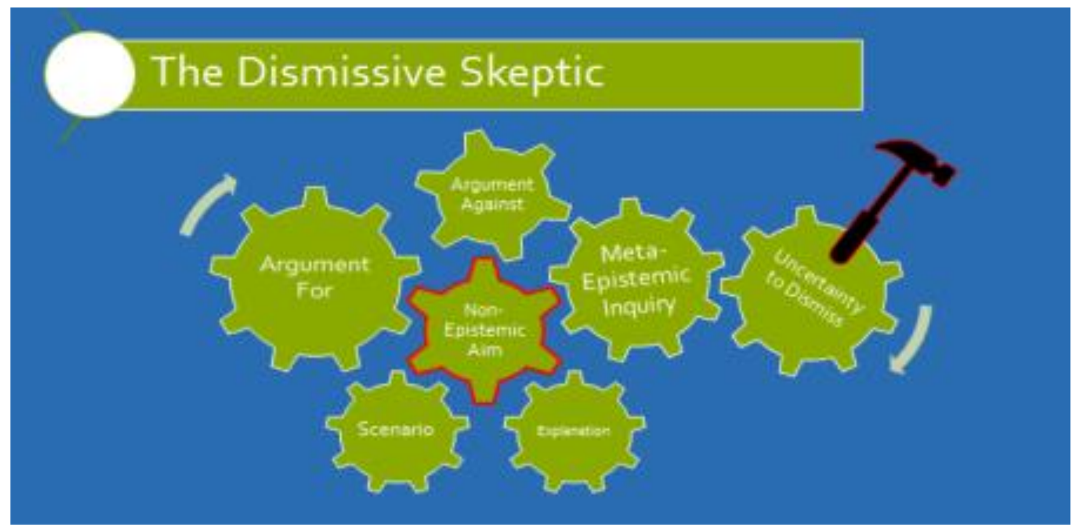
Table 3 - ***Reasoning Practices****, Epistemic*

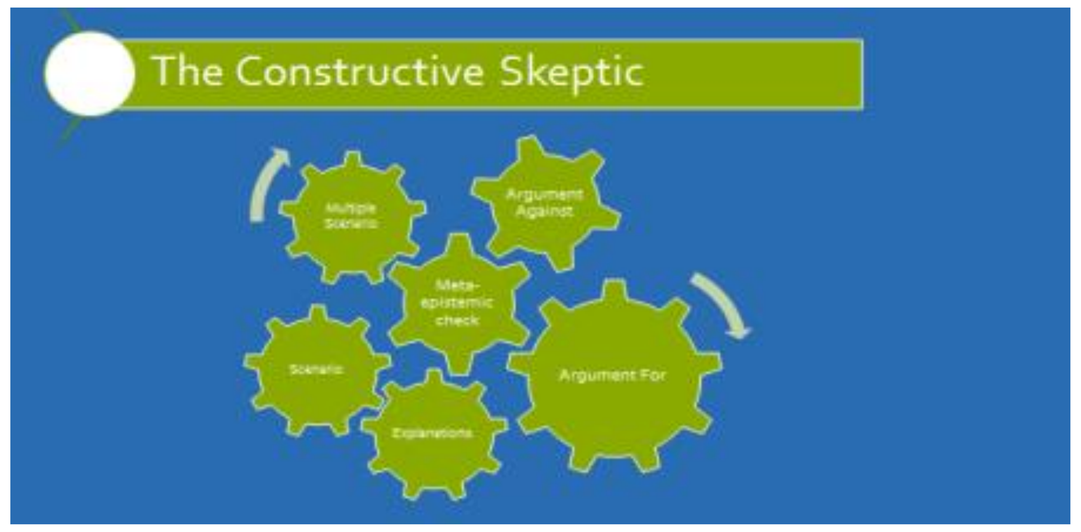
Meta-Epistemic Reasoning Practices	
Seek other aims	a) Preemptive delegitimizing of others' aims. b) Personal affect aside to examine from other aims.
Diversity assumptions/knowledge domains	Various ways of knowing and types of knowledge. "Are multiple sources of knowledge used and different types of knowledge incorporated?"
Possibilities of the imagination or seeking other designs not explored yet	Something different might work than what we normally would think about. What could this be? Could include governance designs.
Identify uncertainties of my knowledge	What's more known and less known? What might be uncertain about a design element/framework?
Inquiring Reasoning Practices	
Questioning, Modeling, Gathering and Analyzing Data, Cost-Benefit Analysis	

Results

Three Qualitatively Different Engagers – with focus on role of aims







Major Findings

- Different 'knowledge for' aims appear to link with different ideals and ideals sometimes shift as aims shift.
  For example, for one participant who commonly used 'arguments for' the wetland design, linked with universal ideals…when I led her to meta-epistemic aims associated with ethical treatment of ideas, she switched to a focus on models and an 'integrative view of ideal knowledge'.
- Ongoing work on "Epistemologies in practice" can be informed by better understanding aims associated with "meaningful use" of science in "real-world" issues.(Berland, et al., 2016)
- Meta-competencies associated with socioscientific reasoning and sustainability education need a more nuanced attention to difficult topics such as skepticism, uncertainty, and complexity which can be ironically oversimplified.(Romine, et al., 2017; Zeidler, et al., 2009)
- In real-world sustainability problems, optimization is not possible; meta-epistemic aims are necessary to problematize and address multiple perspectives.

Classroom Applications

a) Structure argumentation in classrooms to promote sub-epistemic aims including explanation and scenarios.
b) Help learners become self-aware of their own non-epistemic aims and develop meta-epistemic capacities that put personal aims aside for sound logical evaluation.
c) Set meta-epistemic 'knowledge about aims' for learners and focus on integrating knowledge from various domains/perspectives rather than focusing on answers
d) Have learners evaluate ideas using multiple ideals (not presented but part of coding for this research). Includes, complexity, simplicity, integration, alignment to local or scientific knowledge, et.c.
e) Embed learning in locally important contexts, and while exploring topic, emphasize local 'knowledge about' aims.
f) Help leaners work with nuances between the known and unknown so that they utilize it as a driver for sustained engagement and know how to recognize exaggerated uncertainty.

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