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Teaching and research in SCIL 101: Science and Decision-making for a Complex World

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Title
Teaching and research in SCIL 101: Science and Decision-making for a Complex World

Abstract
SCIL 101 “Science and decision-making for a complex world” is the new introductory core class for all of the students in CASNR. The learning objectives are targeted toward developing students’ science literacy skills. The course will be described, as well as findings from on-going science literacy research that investigates indicators of formal and informal decision-making in the course.

Teaching and research in SCIL 101: Science and Decision-making for a Complex World

Jenny Dauer

Assistant Professor in Science Literacy

School of Natural Resources

Science Literacy is…

- More that just basic knowledge of science facts.
- Understanding scientific processes and practices.
- **Familiarity with how science and scientists work.**
- **A capacity to weigh and evaluate products of science.**
- **An ability to engage in civic decisions.**

NRC (2016) Science Literacy Concepts, Contexts & Consequences

Science-informed decision-making

The need to emphasize decision-making as part of science education has long been noted by the scientific community, as well as by science educators themselves

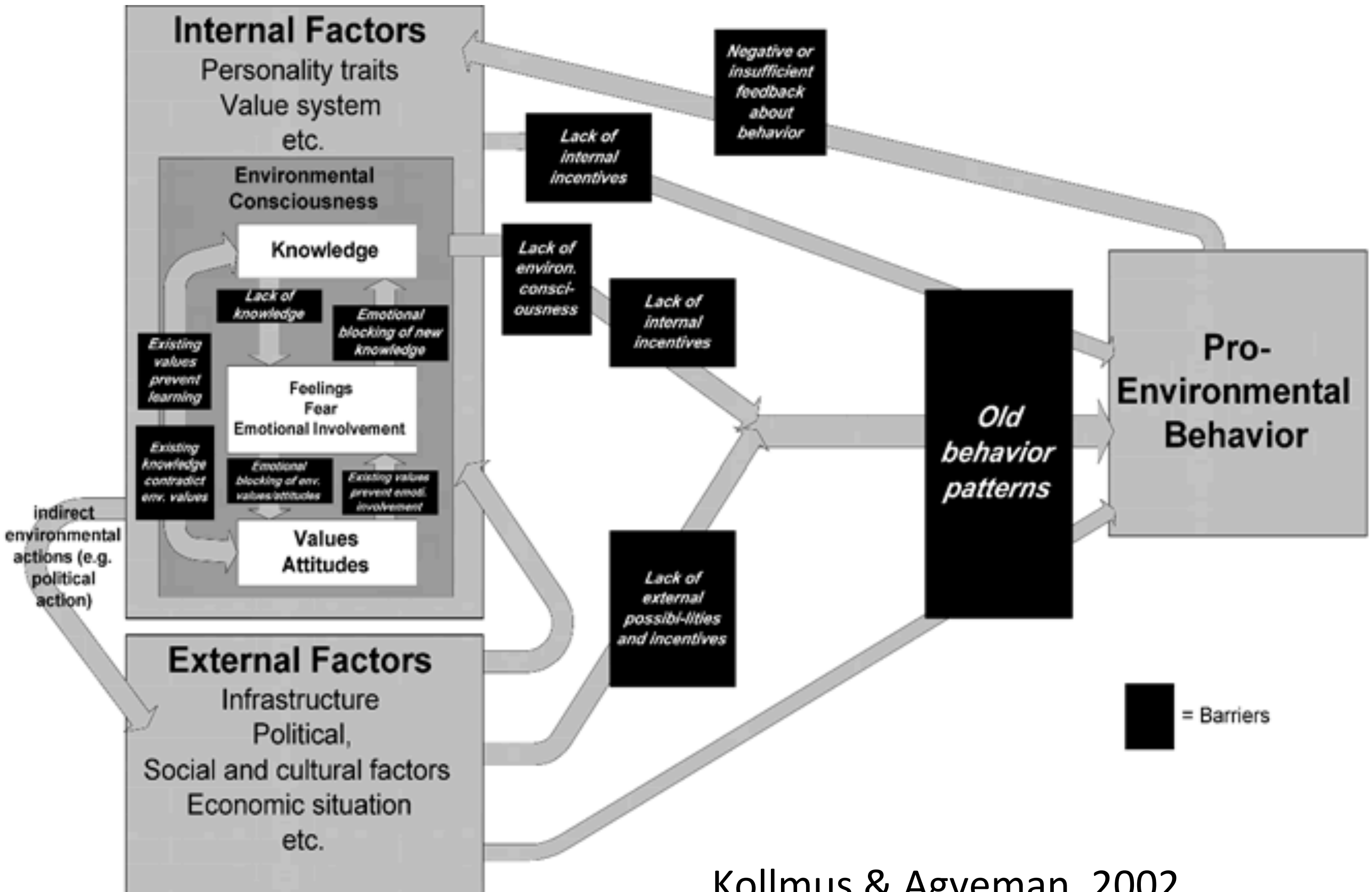
Aikenhead, 1985; Kolstø, 2006; Millar & Osborne, 1998; Zeidler, Sadler, Simmons, & Howes, 2005

Role of Science Education

- What does “science education to improve student decision-making” look like?

- Traditional view– teach student science content knowledge and they will make better decisions

Lack of relationship between science knowledge and decision-making



Kollmus & Agyeman, 2002

How do people form attitudes and opinions that drive decision-making?

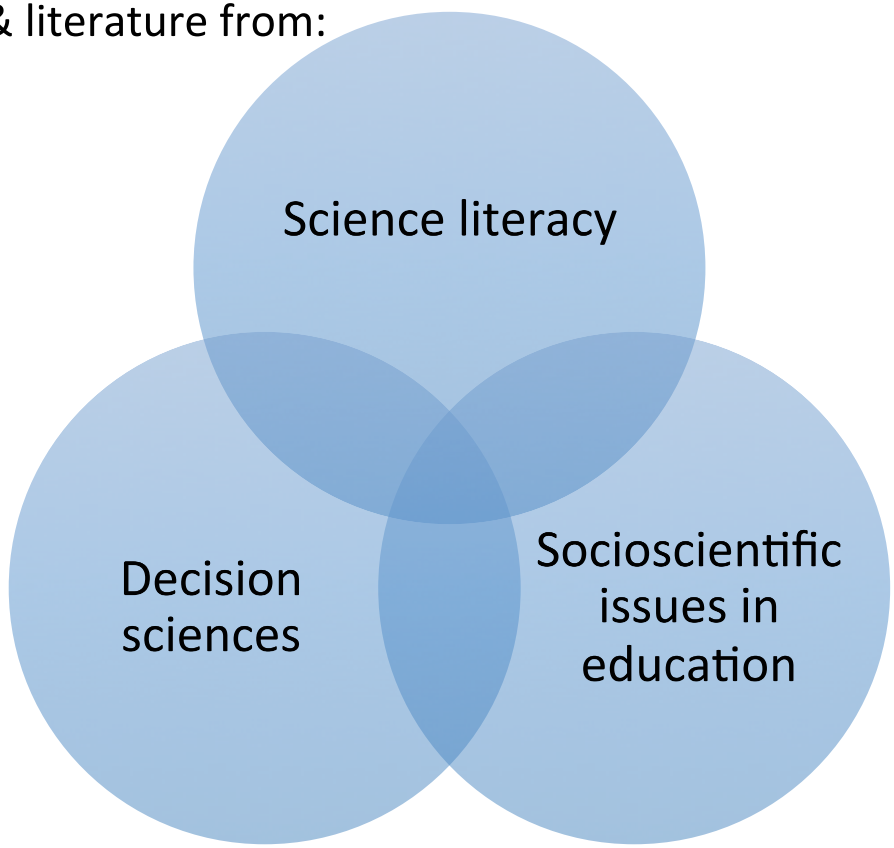
- Privileging knowledge in the opinion forming process is overly simplistic.
- Individual factors other than knowledge can have a significant influence on attitudes towards SSIs

NRC (2016) Science Literacy Concepts, Contexts & Consequences

…they go on to highlight three things: Media use, value predisposition, trust

Creating a course around decision-making as a <u>practice</u>

Drawing on theory & literature from:



Challenges for students and decision-making

- Values sometimes dominate students' thinking at the expense of seeking additional scientific information that would clarify different choices (Grace & Ratcliffe 2002, Sadler 2004, Hong & Change 2004)
- The ability to explicitly weigh tradeoffs seems to be difficult for students in general, and may be due to the difficulty of prioritizing conflicting values (Grace 2009, Eggert & Bogeholz 2009, Jimenez-Aleixandre 2002, Kolsto 2006, Seethaler & Linn 2004)
- Students struggle to integrate knowledge gained in science with real-world problems. (Kolsto 2006, 2001)

Two types of decision-making

Informal decision-making

- Used to make thousands of decisions on a daily basis
- Uses emotive, intuitive and cognitive reasoning
- Does not notice uncertainty
- Subject to cognitive biases
- Based on "value judgments"

Formal decision-making

- Most important to use with challenging, ill-structured problems
- Uses deliberate, rational and effortful reasoning
- Notices uncertainty
- Tools are used to reduce cognitive biases
- Based on optimizing a suite of values

Arvai et al 2004; Hammond et al 1999; Kahneman, 2011; Gregory et al 2012; Covitt et al 2013

Dauer, Lute, Straka in press

What is a GOOD decision?

1. Demonstrates understanding of technical & scientific information
2. Effectively uses a decision support tool to reduce cognitive biases
3. The decision-maker makes choices that address their prioritized values, objectives and concerns

Wilson & Arvai 2006; NRC, 2005

Flagship course required by all majors in the College of Ag Sci & Natural Resources

~550 students per year

SCIL 101: Science and Decision-making for a Complex World

Most common majors:
Hospitality, Restaurant & Tourism Management 17%
Animal Science 12%
Pre-Veterinary Medicine12%
Agricultural Business7%
Forensic Science 7%
Fisheries & Wildlife 5%
(the remaining 40% comprises 28 other majors)

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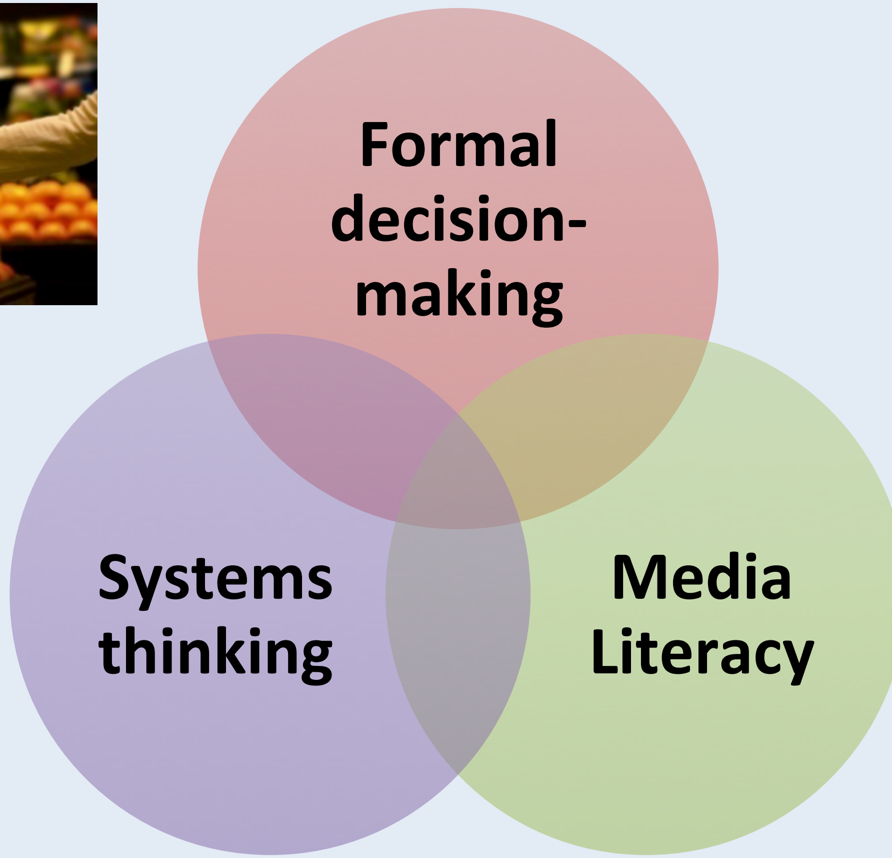
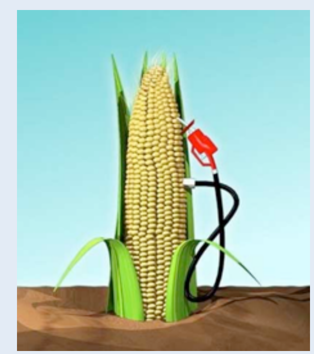
Science Literacy Learning Goals



Socioscientific issues



Dauer & Forbes, 2016 SECEIJ

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Structure of SCIL 101

Each academic year:

- 600 students
- 5 lecture sections (active learning strategies, peer learning)
- 5 other faculty instructors
- 10-14 Graduate student Learning Assistants

Fast and Slow Thinking Frame in SCIL 101

Fast thinking has its place & importance, but when it's really important that we don't make a mistake– slow thinking is better.

Issues that are important enough to do slow thinking:

- How do we impact other living animals on our planet?
- How do we create a sustainable and economically feasible source of energy?
- How do we best use the limited clean water that we have?
- How do we sustainably feed 9 billion people?

All of these issues are incredibly complicated and complex, with no "right" answer!

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Framework for Decision-Making

1. **Define the issue**
2. **Criteria**: What are you objectives/values? How will you evaluate potential solutions?
3. **Options**: What are the options?
4. **Information**: What additional information do you need to help you make the decision? What is the scientific evidence involved?
5. **Analysis**: Discuss each option weighed against the criteria.
6. **Choice**: Which option do you choose?
7. **Review**: What do you think of the decision you have made? How could you improve the way you made the decision?

Ratcliffe, 1997; Grace, 2009; Hammond et al. 1999

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Step 4: Information & **Step 5:** Analysis of options and value trade-offs

OPTIONS

CRITERIA

	Status Quo		**Second Generation Biofuels**		**Electric Cars and Renewable energy**		**Fly & drive less**	
	Metric:	Performance score:	Metric:	Performance score:	Metric:	Performance score:	Metric:	Performance score:
Fewest Greenhouse Gas Emissions	1,545 million metric tons	1	9 pounds per gallon	3	5,556 pounds	4	781 million pounds	2
Weight: .2	.2		.6		.8		.4	
Economic benefit to farmers & rural communities	H	3	H	3	M	2	L	1
Weight: .5	1.5		1.5		1		.5	
Renewable Fuel	No	1	yes	4	yes	3	somewhat	2
Weight: .3	.3		1.2		.9		.6	
Total weighted performance score:	2		3.3		2.7		1.5	

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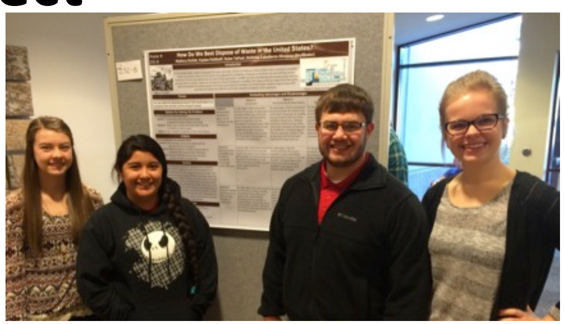
Learning Tasks in SCIL 101

Summative Assessments

For each of the 4 SSIs

- Evaluating relevancy, accuracy, reliability and bias in popular news articles & dissecting peer-reviewed articles.
- In groups seeking scientific information to evaluate the consequences of each option.
- As individuals, weighing the criteria to represent personal values, then working through all 7 decision-making steps and coming to a final decision.

Final group project



Research in SCIL 101

1. How does the course impact students' ability to seek, evaluate and apply scientific information to decision-making?
2. Do students effectively use a decision-making tool (the seven steps)?
3. What are barriers for students in examining value-tradeoffs among options for solving the problem?
4. What is the impact of the course in general? (socioscientific reasoning, civic engagement, attitudes of collaborative learning, media literacy etc.)

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Some findings to report…

Biofuels as a Socioscientific Issue

To understand biofuels decisions:

Students need specific scientific knowledge about matter and energy in processes like photosynthesis, cellular respiration and combustion that are often challenging.

Students need to weigh and leverage economic, environmental and social values along with scientific information to navigate decision about biofuel technology

Biofuels Research Questions/Goals

1. **How do students' values play a role in their thinking about biofuels?**
2. **Describe student thinking about biofuels**
3. Document how SCIL 101 influenced the quality of students' personal reasoning about their position on biofuels

Dauer et al. *in press*

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Transfer task

Fall 2015

Unstructured pre-test decision → **Structured decision-making using 7 steps** → **Unstructured post-test decision**

Data Collection & Analysis

Unstructured Pre and Post opinions on biofuels

"Our culture is energy hungry! A relatively new way to solve our energy needs is to use biofuels. Biofuels are fuels made from living or recently living organisms. There are many sources of biofuels that create ethanol or diesel. A commonly used biofuel is corn ethanol. Currently, approximately 40% of the corn grown in the U.S. is used to create ethanol fuel. Corn ethanol is a boost to rural farmers, is a domestic source of energy and some evidence suggests it may reduce carbon dioxide emissions into the atmosphere. Some people point to problems with corn ethanol including "food vs. fuel," sustainability, deforestation, and water resources.

1) What do you think should be done about this problem? Should we burn corn ethanol for energy?

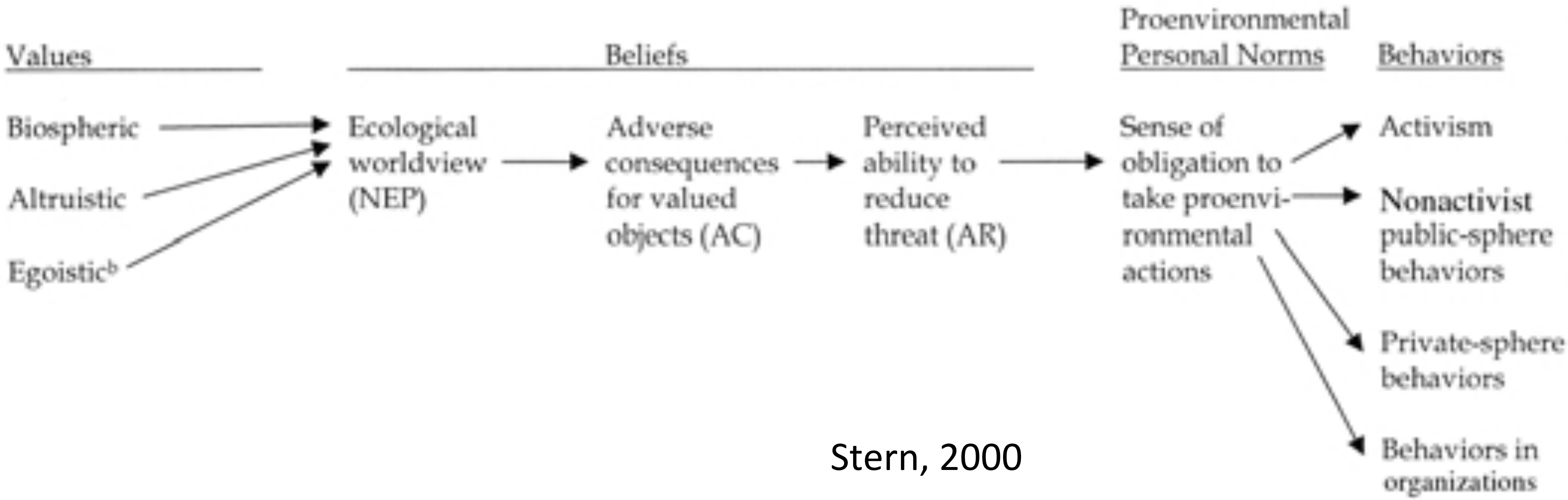
2) Why should we do it/not do it?"

Dauer et al. *in press*

Data Collection

Value-Belief-Norm (VBN) Theory

Causal chain that moves from relatively stable, central elements of values, to beliefs and personal norms and then to behavior.



Stern, 2000

Data Collection

Value Orientation survey

- altruistic, biospheric, egoistic
  - 12 items
  - 8-point scale (-1 = “opposed to my values,” 1= “not important” to 7=“extremely important”)
  - to statements such as “control over others, dominance” (egoistic) “equal opportunity for all” (altruistic) and “protecting natural resources” (biospheric)
- Students’ likert scale selections to the 12 statements were averaged across all statements within each of the 3 value orientations, **“Bio-Ego” variable created**

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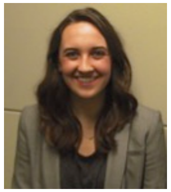
The “Bio-Ego” value orientation score that we calculated predict pre-survey position (*p*<0.001) but not post-survey position (*p*>0.05)

Dauer et al. *in press*



Olivia Straka
UCARE student

Circles include sample size and mean “Bio-Ego” value orientation in italics.

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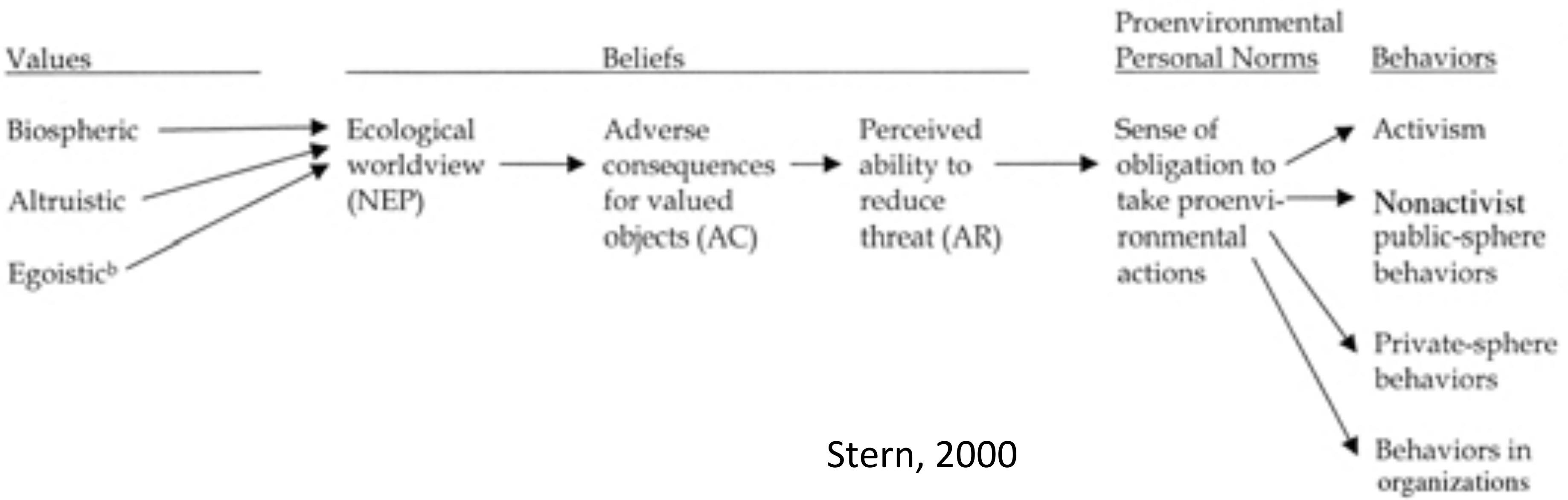
Indicators of formal and informal decision-making?

Value orientations are more likely to predict students' stances when students are engaging in informal reasoning (i.e. when students were using a "value-heuristic" to make a decision)



Stern, 2000

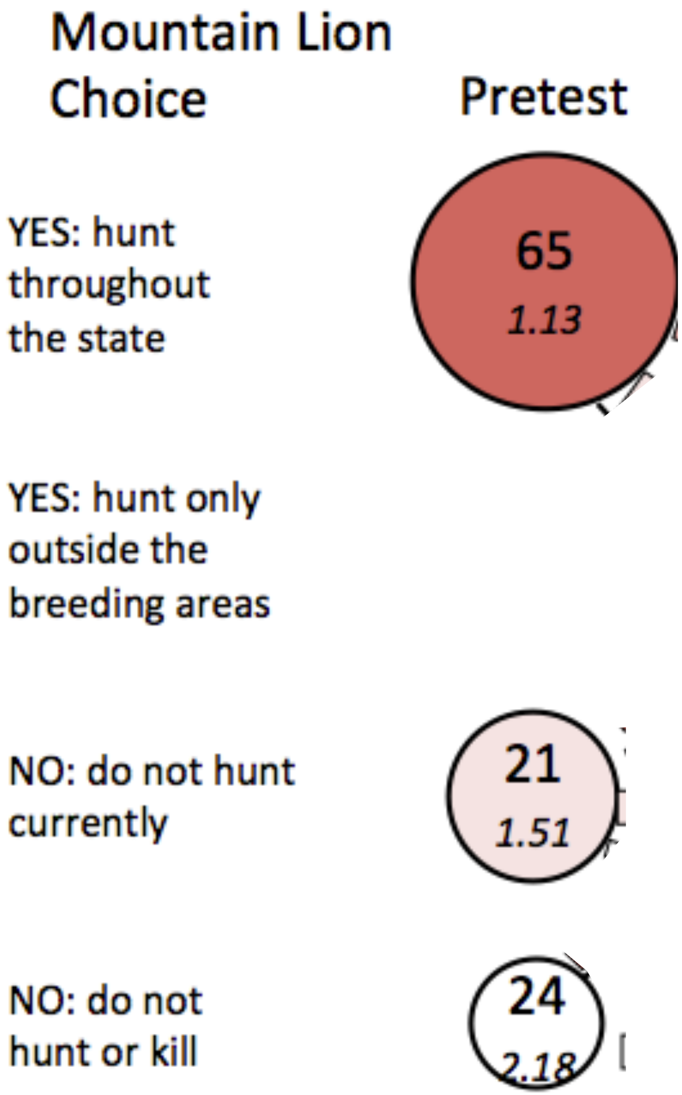
Indicators of formal and informal decision-making?

- Student practice using formal decision-making practices was intended to reduce cognitive biases and aid recognition of multiple relevant values, consequences, and tradeoffs.
- A portion of students in the course changed their stance on biofuels in a direction that was less predictable based on value orientation, which may be an indication that they were less likely to make a quick, heuristic-based judgment about what we should do about corn ethanol by the end of the class.

Qualitative analysis of student justifications for their position

At the end of the course students were more likely to discuss several themes:

1) using an alternative technology or biofuel feedstock beyond corn ethanol (5 times more likely)
2) the food versus fuel debate (3 times more likely)
3) Concern about natural resources (water, soil) depletion (2 times more likely)



The "Bio-Ego" value orientation score that we calculated predict pre-survey choice (p<0.05) but not post-survey position (p>0.05)

Ashley Alred
MS student

Circles include sample size and mean "Bio-Ego" value orientation in italics.

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Indicators of formal decision-making in mountain lion issue

- Again, value orientations were predictive of student decisions at the beginning of the class, but not at the end of the class
- Students may have been doing more nuanced, logical formal decision-making at the end of the course that represented multiple values

Research Conclusions

- We find some indications that students may be examining value-tradeoffs (formal decision-making) by the end of the course.
- More work is need to understand the efficacy of a the seven steps for decision-making in students science literacy skills, and how to better support students' application of scientific info to problem solving.
- More work is needed on the impact of the course in general.

SCIL 101

- We hope the course can be a model for a new approach to the role of science education in science literacy
- Overall positive response from the students
- Open for your feedback – Tu/Th in 107 Hardin Hall

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