PLAYING THE "DAM" GAME:

EVALUATING THE SUITABILITY OF SCIENCE-BASED ROLE-PLAY SIMULATIONS AS TOOLS FOR LEARNING ABOUT SUSTAINABLE WATER FUTURES

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1. What's the Problem?

PROBLEM 1:

- Complex interactions between society, ecology, and economy, especially within the context of sustainability shed light on a particularly challenging set of "wicked" problems.[1,2,3,4]
- "Wicked" problems are complex! They involve a variety of stakeholder perspectives and are associated with high degrees of uncertainty.
- Scholars call for "new Social Contract for science" that addresses societal needs[5,6] and these "wicked" problems. That's were Sustainability Science (SS) comes in!
- **Sustainability Science** - problem focused and use inspired[7,8,9,10,11,12,13]
  - Links knowledge with action
  - Co-production of knowledge
  - Stakeholder engagement
  - Place-based
  - interdisciplinary integration & organizational innovation

But, how do we apply SS to water resource management?

PROBLEM 2:

- Dams are "wicked" problems!
  - ~14,000 dams in New England[14,15]
  - Full of tradeoffs (e.g. fish passage vs. hydropower production vs. historic preservation vs. property values)
  - Many over 100 years old and pose safety risks
  - Many stakeholder perspectives and interests
  - Decision-making over water resources is often contentious and arguments about what to do with existing dams are polarizing

PROBLEM 3:

- Marginalization & limited use of science in decision-making[6,16]

2. Addressing Knowledge Gaps

- **To support complex water negotiations we need process tools that:**
  1. **provide safe spaces for stakeholders[17] to collaborate and innovate**
  2. **enable use of robust & "usable" science in decision-making**
- Science-based role-play: In a role-play simulation, stakeholders play an assigned role & engage in a mock decision-making process around complex "dam" issues for a set period. System dynamics models are visual tools used to simulate the interactions and feedback within a complex system.

Science-based role-play negotiations =

Science-based Model
(System Dynamics Model)

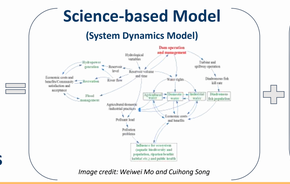

Image credit: Weiwei Mo and Cuihong Song

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Role-play Simulation

Image credit: Natallia L. Diessner

3. Research Question

How do science-based role-play negotiation simulations impact learning, use of science in decision-making, and innovative problem-solving around management of dams in New England?

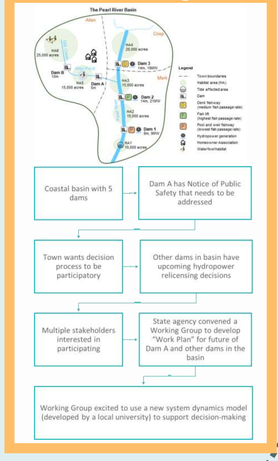
4. Design Methods

To answer this question, we developed a science-based role-play negotiation simulation and tested it via a series of two workshops (Table 1) with stakeholders in New England. Stakeholders in attendance represented diverse sectors and dam-related interests.

Table 1. *Role-play negotiation workshop characteristics.*

	Workshop #1		Workshop #2	
State	New Hampshire (NH)	Rhode Island (RI)	New Hampshire (NH)	Rhode Island (RI)
# of Participants	25	14	21	7
Date	Jan 2019	Jan 2019	May 2019	May 2019
Role-playing	Stakeholders play same roles		Stakeholders play alternative roles (different from their real-life roles)	
Purpose	Inform role-play & model design		Test role-play & model	

Role-play Setting



Role-play Characters

Table 2. *Character roles designed for the science-based role-play. Role design was informed by a Stakeholder Assessment, consisting of 36 stakeholder interviews.*

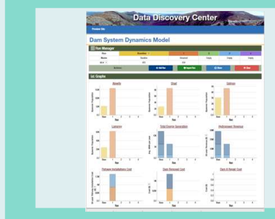
Who is attending today's meeting? (character roles)	Type of stakeholder
Federal Agency of Natural Resources (FANR)	Federal government.
State Water Resources Division (WRD)	State government.
Historic Preservation Agency of the State (HPAS)	State government.
HydroEnergy, LLC.	Hydropower developer and operator; Dam owner.
Allen Pond Homeowner Association (HOA)	Property owners along Allen Pond.
Rivers-R-Us	Non-governmental, non-profit organization.
Town of Allen Municipal Official	Municipal government; Dam owner.
Facilitation team to help run the meeting and assist the group in using the system dynamics model	Not a stakeholder; Neutral, third-party.

- Participants make 3 decisions during mock negotiation: which dams & alternatives, who is responsible for implementation, and who pays?

Negotiation Tools

1. Role-play General & Confidential Instructions[18]

2. Participants interact with a **system dynamics model** via a web-based user interface during negotiation[18, 19]



5. Evaluation Methods

Measured Outcomes:

- General workshop experience
- Relational Learning[20]
- Normative Learning[20]
- Relational Learning[20]
- Product Legitimacy[21]
- Product Salience/Relevance[21]

Instruments used to measure outcomes:

- Post-intervention debriefing sessions *(QL; n=2)*
- Post-intervention interviews *(QL; n=4)*
- Pre- and post-intervention surveys *(QL; QT; n=56 surveys; n=28 pre/post survey pairs)*
- Pre- and post- intervention concept maps[20, 22] *(QL; QT; n=46 maps; n=23 map pairs)*

Key:
QL = qualitative data

QT = quantitative data

6. Evaluation Results

Table 3. *Shifts in cognitive, normative, and relational learning indicated by participant responses to propositional statements in the pre- and post-workshop surveys. Significance at the 0.05 level is represented in yellow and at the 0.1 level in orange.*

	COGNITIVE LEARNING Questions	Pre-survey Mean (X_1)	Post-survey mean (X_2)	Change/Diff ($X_1 - X_2$)	2-tailed t-test p-value	Wilcoxon sign-rank p-value
Cognitive	Q1_1. I know a great deal about the social impacts of dams.	3.857143	4.178571	-0.321428	0.0475	0.0665
	Q1_2. I know a great deal about the biological and/or physical impacts of dams.	4.178571	4.357143	-0.1785714	0.2832	0.2513
	Q1_3. I know a great deal about feedbacks and tradeoffs associated with different dam management options (e.g. removal, repair, added fish passage or added hydropower).	3.928571	4.142857	-0.2142857	0.2643	0.4523
	Q1_4. I know a great deal about how dam decisions are made.	3.464286	3.964286	-0.5	0.0202	0.0305
	Q1_5. I know a great deal about others' perspectives on dam decisions.	3.535714	3.642857	-0.10714129	0.5414	0.7317
	Q1_7. Dams are generally in worse physical condition than they were 10 years ago.	3.928571	4.142857	-0.2142857	0.2971	0.4618
	NORMATIVE LEARNING Questions	Pre-survey Mean (X_1)	Post-survey mean (X_2)	Change/Diff ($X_1 - X_2$)	2-tailed t-test p-value	Wilcoxon sign-rank p-value
Normative	Q1_6. The benefits of dams outweigh their negative impacts.	2.714286	2.785714	-0.0714286	0.752	0.5577
	Q1_8. Decisions about dams are well informed.	3.071429	2.892857	0.1785714	0.3262	0.6204
	Q1_9. Scientific models and monitoring data should inform dam decisions.	4.178571	4.571429	-0.3928571	0.0537	0.0502
	Q1_10. Scientific model clarity and accuracy are important for reaching good decisions.	4.321429	4.535714	-0.2142857	0.2643	0.2783
	Q1_11. Input from diverse stakeholders should inform dam decisions.	4.357143	4.535714	-0.1785714	0.4449	0.5226
	Q1_13. Decisions about dams are fair.	2.928571	3	-0.0714286	0.5732	0.7445
	Q1_16. New policy options are needed for dam decisions.	3.535714	3.928571	-0.3928571	0.0386	0.053
	RELATIONAL LEARNING Questions	Pre-survey Mean (X_1)	Post-survey mean (X_2)	Change/Diff ($X_1 - X_2$)	2-tailed t-test p-value	Wilcoxon sign-rank p-value
Relational	Q_12. I feel comfortable sharing knowledge and information to inform dam decisions.	4.464286	4.464286	0	1	0.7445
	Q1_14. I trust municipalities and state agencies to take a lead role in facilitating dam decisions.	3.464286	3.214286	0.25	0.27	0.3269
	Q1_15. I trust nongovernmental organizations to take a lead role in facilitating dam decisions.	3.035714	3.214286	-0.1785714	0.421	0.4534

Key: Strongly disagree (1); Somewhat disagree (2); Neither agree nor disagree (3); Somewhat agree (4); Strongly agree (5)

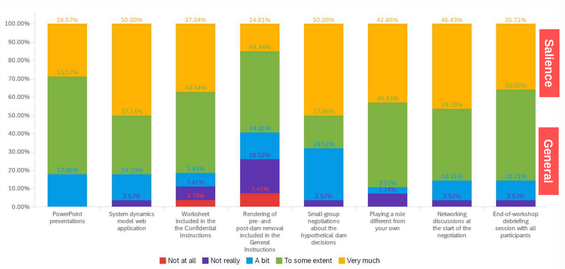


Figure 1. *Participants' responses to how useful different elements of the science-based role-play workshop were for their personal learning experience.*

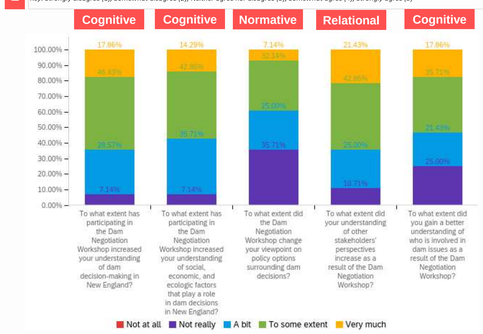


Figure 2. *Participants' responses to post-workshop survey questions. Responses provide evidence of cognitive, normative, and relational learning.*

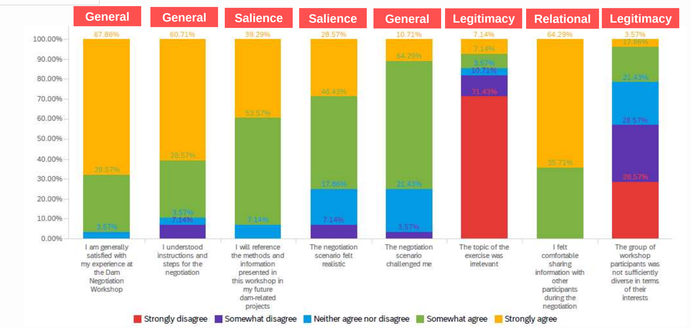


Figure 3. *Participants' responses to post-workshop survey questions. Responses provide evidence of cognitive, normative, and relational learning, as well as legitimacy and salience of the science-based role-play.*

Cognitive

Figure 4. *Example concept map.*

- **Concept maps help evaluation shifts in cognitive learning[20,22]**
- **Concept Map Centrality:** refers to proximity of themes to the map's core. Indicator of theme saliency to "Key aspects of dam decisions." The lower the centrality score the more "salient" that theme is perceived.
- **Concept Map Specificity:** refers to frequency of concepts and extent to which they are described in detail

Cognitive

Figure 5. *Concept map centrality results. Most themes were less "central" in the post-workshop maps. Results suggest that participants learned that decisions around dams rely on more than just one "central" issue and are more nuanced.*

Cognitive

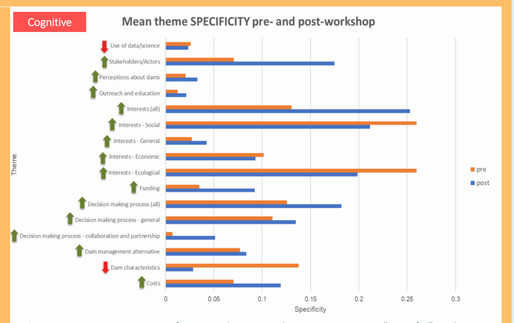


Figure 6. *Concept map specificity results. Most themes were more "specific" in the post-workshop maps. Participants' described dam-related issues in greater detail in the post-maps. Participants seem to better understand the complexity surrounding dams after their participation in the workshops.*

7. Preliminary Insights

Learning → Sustainability

- Participants were generally satisfied with the workshop
- Evidence that workshop led to shifts in:
  - cognitive learning (this is consistent with Haug et al., 2011)
    - about ecological, social, and economic tradeoffs, as well as other topics related to dam decisions
  - normative learning (this is in contrast to Haug et al., 2011)
    - participants' norms and beliefs related to important of scientific models and need for new policy options shifted after the workshops
- Some evidence of relational learning (in the QL data)
- Different process design elements have different impacts on learning (e.g. role-switching vs. vs. model)

Process & Methods Matter

- Process matters for people's ability to be innovative, create new solutions, and learn
- Mixed-methods approach allows for a holistic overview of workshop outcomes

Use of Science in Decision-Making

- Participants find the role-play a salient and somewhat legitimate product, and envision using it in their work
  - But recognize its limitations in terms of political, regulatory, & site-specific constraints
- Participants are interested in new policies and process approaches
- Holds promise for supporting more collaborative and science-based decisions concerning water resource management

References

1. Rittel & Webber (1973); **2.** Batie (2008); **3.** Balint et al. (2011); **4.** Kreuter et al. (2014); **5.** Lubchenco (1998); **6.** Lubchenco (2017); **7.** Clark and Dickinson (2003); **8.** Hart et al. (2015); **9.** W. C. Clark & Dickson, (2003); **10.** Kates et al. (2001); **11.** Meyer et al. (2016); **12.** Miller (2013); **13.** Miller et al. (2014); **14.** Gold et al. (2016); **15.** Magilligan et al. (2016); **16.** Karl et al. (2007); **17.** Rumore et al. (2016); **18.** Diessner et al. (2019) - link to role-play negotiation introductory video: https://scholars.unh.edu/nh_epscor/3/; **19.** Song et al. (forthcoming) – link to model web-based user interface: https://ddc.unh.edu/dam-system-dynamics/; **20.** Haug et al. (2011); **21.** Cash et al. (2003); **22.** Morine-Dershimer (1993).

Coming soon: public release of our science-based role-play with teaching instructions!

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