

# Deep Knowledge Integration Across Disciplines: The EMBeRS Method

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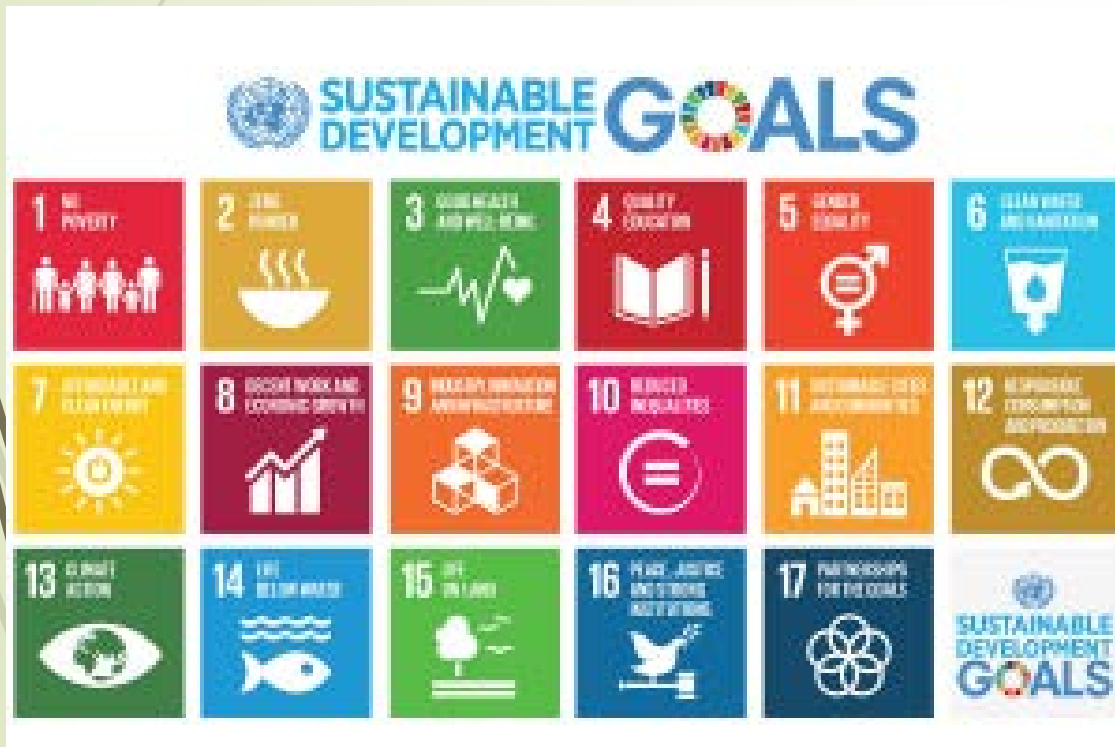


# AGENDA

1. Need for interdisciplinary research in sustainability science
  2. Challenges of interdisciplinary research
  3. The EMBeRs method
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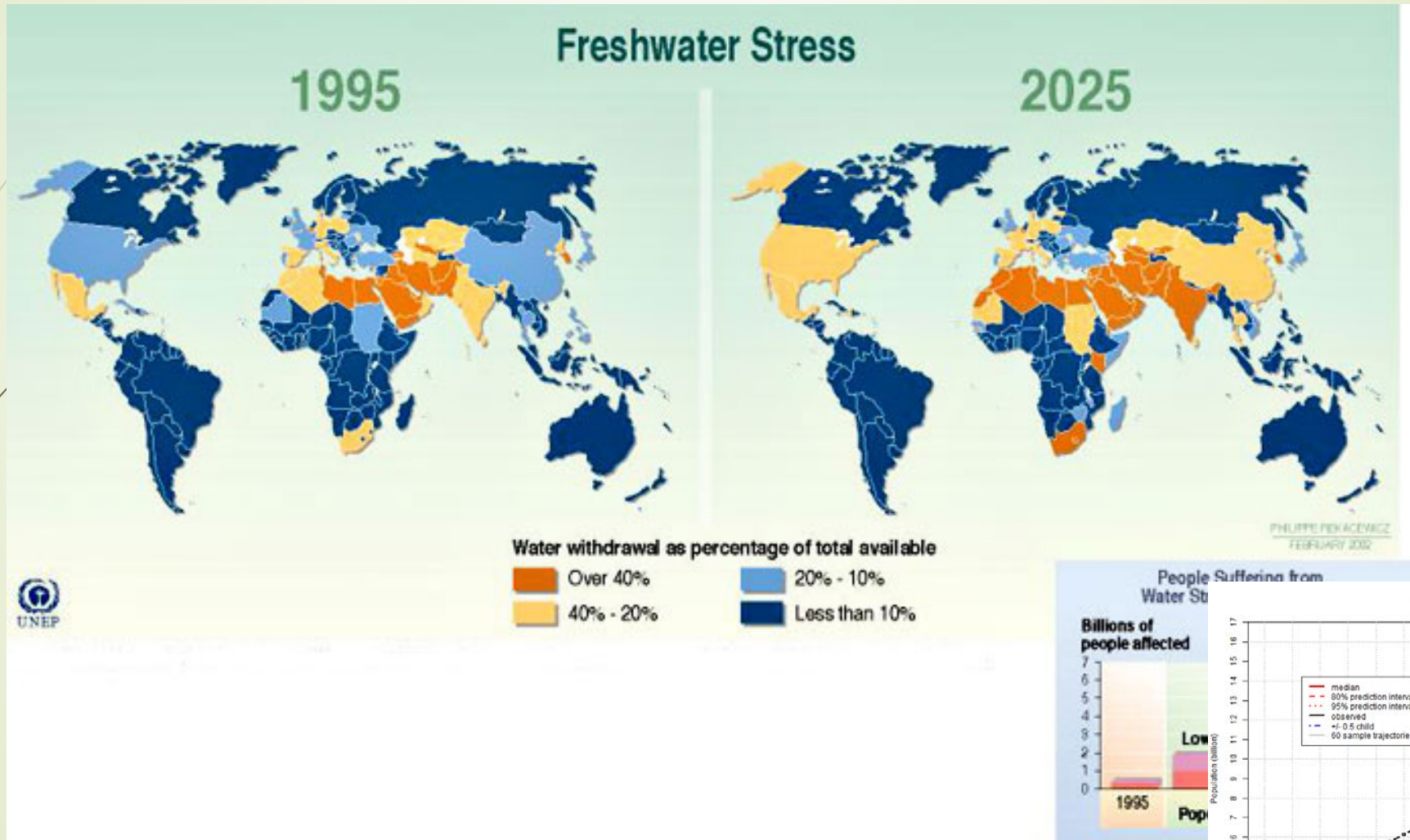
# United Nation's 2015 Agreement 17 Sustainable Development Goals for 2030

UN World Commission on Environment and Development: "Sustainable development is development that meets the needs of the present *without compromising the ability of future generations* to meet their own needs."



1. No poverty
2. Zero hunger
3. Good health
4. Quality education
5. Gender equality
- 6. Clean water**
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, justice and strong institutions
17. Partnerships for the goals

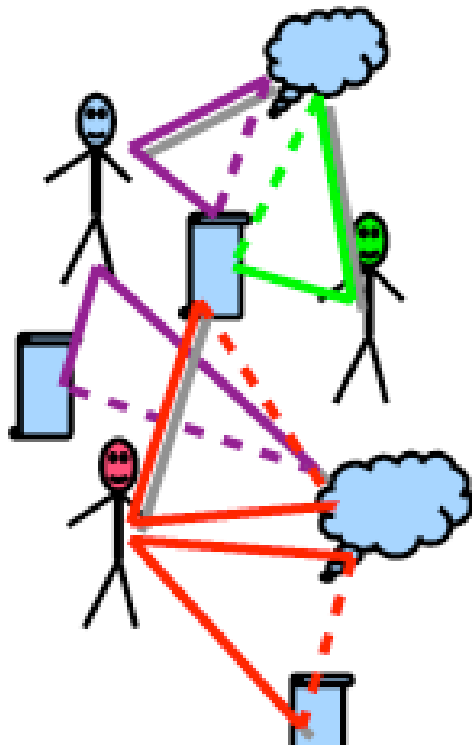
# Depletion of Freshwater Resources



United Nation's Environment Programme

1. Need for interdisciplinary research
2. Challenges of interdisciplinary research
3. The EMBeRS method

# Challenges of Interdisciplinary Research



Process of developing a shared research vision

National Academy of Sciences (2015)  
Enhancing the Effectiveness of Team Science

1. High diversity
2. Deep knowledge integration
3. Goal misalignment
4. Task interdependence
5. Permeable boundaries
6. Large size
7. Geographic dispersion

★ Focus here



# REALITY: Scientists & Engineers Collaborating



## Study computation

"First you must convert  
your data to RDF and  
then we can use  
automated  
reasoning..."



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# Practical lessons learned

No structure  
Ad hoc dialogue  
No progress

Firm structure  
Research presentations  
No understanding



How NOT to do this

1. Need for interdisciplinary research
2. Challenges of interdisciplinary research
3. The EMBeRS method



## Employing Model-Based Reasoning in Socio-Environmental Synthesis

Question of interest: How can we *more effectively* engage across disciplines to overcome the challenges of deep knowledge integration?

Approach: Apply *theories from cognitive and social sciences*:

- Transformative learning
- Experiential learning
- Model-based reasoning
- Boundary objects







# The EMBeRS Method

- Lightly structured, **participatory** process
- **Explore** the problem space from **different perspectives**
- Emphasis on **informal teaching and learning**
- **Co-create visual representations** of the problem (“boundary negotiating objects”)
- Recognize that ***shared vision emerges through time***

# EMBeRS Workshops

- Summer workshop for PhD students
- 2016, 2017 – 10 days each
- 13 students each workshop
- Recruited from large, interdisciplinary NSF projects related to water
- Different disciplines, different institutions



# Data Collection

## Environmental education expert (Dr. Shirley Vincent)

- ▶ Surveys, interviews with students



## Learning research team (Dr. Kate Thompson)

- ▶ Photos, videotape, audio recording
- ▶ Documents produced during workshop





# Evaluation outcomes

- ▶ Transdisciplinary Orientation scores increased 10%
- ▶ Confident in their ability to effectively participate in and lead interdisciplinary teams, and teach transdisciplinary research skills to others
- ▶ Developed competencies and understanding in 16 specific areas

Pennington et al. (submitted)





# Learning research team

- ▶ Thematic analysis of student reflections:
  - ▶ Shifted concept of groups as needing to be goal oriented to productive, and from discussing conflict to trust and culture.
- ▶ Retrospective pre/post evaluation surveys:
  - ▶ Improvement in the value placed on self-awareness of their role in a group
- ▶ Analysis of the guided reflections at the end of each day:
  - ▶ Value of informal interactions in building trust and a supportive culture in groups
- ▶ Textual analysis of student writing:
  - ▶ Variety of approaches to interdisciplinary writing can impact on the final product submitted
- ▶ Linguistic analysis of the groups' final output:
  - ▶ Two groups did produce an interdisciplinary research proposal
- ▶ Further research is examining the development of boundary negotiating objects



# Long-term outcomes & transfer

Students consistently remark that they are finding the methods and tools they gained from the EMBeRS workshop extremely useful in a wide variety of ways:

- Within a variety of **research groups**
- To structure **collaborations** between research colleagues and project stakeholders
- To structure **dissertation design**
- Designed and led an **engineering class** period
- Led a **seminar** within a research group that was attended by a Center Director from Swaziland – **who then hosted** a two day workshop at the Center
- As a talking point with **job interviewers**

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Killion, A. K., K. Sterle, E. Bondank, J. Drabik, A. Bera, S. Alian, K. Goodrich, M. Hale, R. A. Myer, Q. Phung, A. M. Shew, and A. W. Thayer. 2018. Preparing the next generation of sustainability scientists. *Ecology and Society* 23(4):39. <https://doi.org/10.5751/ES-10395-230439>



*Insight*, part of a Special Feature on [Integration of Social and Natural Dimensions of Sustainability](#)

## Preparing the next generation of sustainability scientists

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**ABSTRACT.** Graduate programs emerging in unive complex socio-environmental systems. Constructing across disciplines and synthesize the social and natu inter- and transdisciplinary research acknowledge the this training is not available in all graduate programs t opportunities. We present perspectives from a group c research in universities across the United States who p training workshop to learn and develop socio-environ autoethnographic study to share pre- and postworksh opportunities. Results reveal that students, regardless that include: (1) lack of exposure to epistemological fr perspectives in his/her research, and (3) variable levels barriers and advance integrative research, students re programs. Students advocate that both internal and sustainability scientists.

iEMSSs International Congress on  
Environmental Modelling and Software



9th International Congress on Environmental Modelling and Software  
Fort Collins, Colorado, USA, Mazdak Arabi, Olaf David, Jack Carlson, Daniel P. Ames (Eds.)  
<https://scholarsarchive.byu.edu/iemssconference/2018/>

## EMBeRS: An Approach for Igniting Participatory Learning and Synthesis


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# Conclusions

- Interdisciplinary research is extremely challenging
  - There is a decade of research on science teams coming out of the cognitive, organizational and social sciences that can help
  - There are many decades of research on learning that can also help
  - Transfer of these theories into meaningful approaches and activities “in the wild” is its own research challenge that must be undertaken by people in their own context
  - Training the next generation to do this more effectively is imperative if sustainability goals are to be reached
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## Employing Model-Based Reasoning in Socio-Environmental Synthesis

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"Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation."



Lighting the fire of  
interdisciplinary  
synergy

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