

Applying ESA's 4DEE Framework to Guide the Development of Ecological Literacy for Non-majors



<https://www.esa.org/4dee/>

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4DEE Framework & Background

- In 2018 ESA endorsed a Four-dimensional Ecology Education (4DEE) curricular framework, recognizing that teaching ecological literacy requires the **integration** of:
 - Teaching the hierarchy of core ecological concepts (CEC),
 - Engaging in updated ecological field data collection and analysis, interpretation, communication practices (EP)
 - Addressing the human environmental interactions (HEI)
 - Connecting ecological concepts to cross-cutting biological themes - structure/function, scales, system change (CCT)
- Non-majors are an important audience who may benefit specifically from a method of teaching that connects ecology concepts and practices to society and important cross-cutting themes
- Our goal is to build a more holistic ecological perspective and awareness along with skills for the large population of non-major students

4DEE Rubric

- 4DEE learning can be designed using the following rubric as a checklist of the parts of each dimension as well as an explanation of the interactions:

| Core Ecological Concepts (CEC) | Ecology Practices (EP) | Human-Environment Interactions (HEI) | Cross-Cutting Themes (CCT) |
|---|--|---|--|
| <ul style="list-style-type: none"> Organisms Population Community Ecosystems Landscapes Biomes Biosphere | <ul style="list-style-type: none"> Natural history Fieldwork Quantitative reasoning & computational thinking Designing & critiquing investigations Working collaboratively Communicating | <ul style="list-style-type: none"> Human dependence on the environment Human accelerated environmental change How humans shape & manage resources, ecosystems, the environment Ethical dimensions | <ul style="list-style-type: none"> Structure & function Pathways & transformations of matter & energy Systems Spatial & Temporal |

| Integration Across Dimensions | | Identification of Interaction by Coverage Item | |
|-------------------------------|-------|--|-------|
| CEC | X EP | | |
| CEC | X HEI | | |
| CEC | X CCT | | |
| EP | X HEI | | |
| EP | X CCT | | |
| CEC | X EP | X HEI | |
| CEC | X EP | X CCT | |
| EP | X HEI | X CCT | |
| CEC | X EP | X HEI | X CCT |

Application of 4DEE Rubric for Non-majors: A Lesson Carbon Cycling Exercise

- In this activity, students work in groups of 3-4, using a given list or pre-made stack of index cards to connect pools & fluxes of carbon
- The provided pools of carbon contain the major sinks of carbon, but also some that should not be used, such as "Sun"
- Students must collaborate to model how carbon moves within the ecosystem and how humans are changing this
- Groups then split and rotate around the classroom to evaluate each others' carbon cycle & the instructor points out common mistakes
- This exercise promotes 4DEE learning by addressing the following dimensions & interactions:

| CEC | EP | HEI | CCT |
|---|---|--|--|
| <ul style="list-style-type: none"> Ecosystems Trophic levels Energy flow Nutrient cycling | <ul style="list-style-type: none"> Quantitative reasoning Modeling Working collaboratively | <ul style="list-style-type: none"> Human accelerated environmental change Climate change | <ul style="list-style-type: none"> Pathways & transformations of matter & energy Systems |

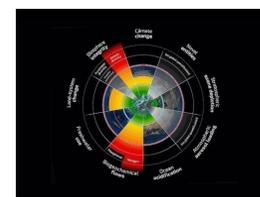
| Integration Across Dimensions | | Identification of Interaction by Coverage Item | |
|-------------------------------|-------|--|--|
| CEC | X EP | Modeling ecosystem processes and movement of carbon | |
| CEC | X HEI | Connecting human involvement to changes in carbon cycle | |
| CEC | X CCT | Practicing systems-thinking to identify relationships for carbon | |
| EP | X CCT | Evaluating pathways for carbon transformation | |



Application of 4DEE Rubric for Non-majors: A Syllabus Socio-Ecological Systems Course

- In this class for non-majors, students are taught ecology, framed around the HEI & from a CCT perspective of systems-thinking
- At Babson College we have three versions of this course with the same learning objectives and frameworks that are taught, but different HEI foci: Urban Systems, Food Systems, & Resiliency Systems
- These classes promote 4DEE learning by addressing the following dimensions & numerous interactions (not shown below):

| CEC | EP | HEI | CCT |
|--|---|--|---|
| <ul style="list-style-type: none"> Organisms Bioreactors & regulators Population Exponential & logistic growth Community Species diversity Competition Stability Ecosystems Trophic levels Food chain Energy flow Nutrient cycling Regulators Landscapes Gradients Biomes Biome types Biosphere Climate change | <ul style="list-style-type: none"> Quantitative reasoning Data skills Modeling & simulation Critiquing investigations Evaluating claims Argument from evidence Working collaboratively Communicating & applying ecology | <ul style="list-style-type: none"> Human dependence on the environment Ecosystem services Human accelerated environmental change Climate change Biomagnification How humans shape ecosystems Natural resource management Ecological stewardship Ethical dimensions Environmental ethics Sustainability Environmental justice Ecological economics | <ul style="list-style-type: none"> Pathways & transformation of matter & energy Systems Spatial & temporal Stability & change Biogeography |



Planetary Boundaries Framework

Application of 4DEE Rubric for Non-majors: A Project Species Conservation Project

- In this project, students work in pairs to become an expert in their assigned IUCN Red List endangered species
 
- They are charged to create a well-researched, written conservation plan, as well as a short video to educate the general public
- They must include all ecologically-relevant information for their species (including drawing the socio-ecological system in which they reside), indicate current threats & propose a conservation plan
- Students are asked to recognize which communities of humans are impacted by the decline of this species and make a case for whether this species should be saved and how feasible it would be
- Students must then watch the videos of their peers and make a plan for how to integrate the information to save the most species or evaluate which are the priority species
- This project promotes 4DEE learning with the following dimensions & example interactions:



| CEC | EP | HEI | CCT |
|---|--|--|---|
| <ul style="list-style-type: none"> Organisms Habitat & niche Population Demography Community Competition Behavioral ecology Ecosystems Trophic levels Food chain Biomes Biome types | <ul style="list-style-type: none"> Critiquing investigations Evaluating claims Argument from evidence Communicating & applying ecology | <ul style="list-style-type: none"> Human accelerated environmental change Climate change How humans shape ecosystems Conservation biology Ecological stewardship Ethical dimensions Environmental ethics Environmental justice | <ul style="list-style-type: none"> Systems Spatial & temporal Biogeography |

| Integration Across Dimensions | | Identification of Interaction by Coverage Item | |
|-------------------------------|-------|---|-------|
| CEC | X HEI | Connecting impacts of climate change to effect on ecosystem functioning | |
| EP | X HEI | Evaluating the claims for human impact on the species | |
| CEC | X EP | X HEI | X CCT |
| CEC | X EP | X HEI | X CCT |

4DEE Recommendations for Teaching Non-majors

- Some likely key CEC for non-majors are: resources & regulators, species diversity, stability, energy flow, nutrient cycling, biome types & global climate change
- Non-majors need to understand EP to de-mystify how ecological research is performed & evaluate it
- An important point of interest for non-majors is HEI and therefore this needs to be central in teaching
- Systems in CCT is an especially helpful emphasis for non-majors as it allows for different ways of thinking and understanding complex and indirect relationships.