Do Models Matter?
Comparing Concept Mapping and Simulations for Student Learning of Ecology Concepts

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Introduction

- Vision and Change calls for reforming how we teach biological concepts; for example using more active learning in the classroom (Freeman et al, 2014)
- Models are used in biology and can be tools to use in the classroom to help simplify complex systems, especially difficult principles such as conservation of matter in ecosystems (Carlsson, 2002)
- Concept-mapping in the classroom facilitates visualization of systems from parts to whole and to map their interactions using arrows (Harrison and Treagast, 2000)
- Simulation models utilized in the classroom allows students to observe those interactions among the components through graphical interpretation (Harrison and Treagast, 2000)

Research Questions

Do students display higher learning gains and engagement levels for matter cycling assessments when given a concept-map activity or a simulation activity?

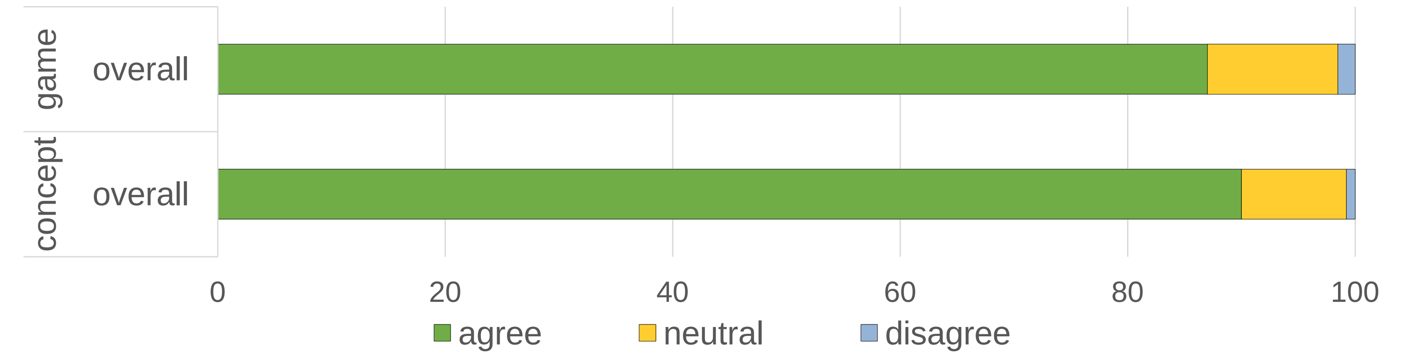
Methods & Results

- Participants were students enrolled in discussion sections of Principles of Biology for Non-majors, taught by graduate teaching assistants
- During the food web and carbon cycle curriculum, 8 discussion sections participated in the concept-map activity and 8 discussion sections participated in the simulation activity
- After each activity, students were asked to fill out student engagement surveys
- Students were asked to participate in a pre and post-test to compare student learning gains
- Students were given an additional post-test short answer question based on the carbon cycle:

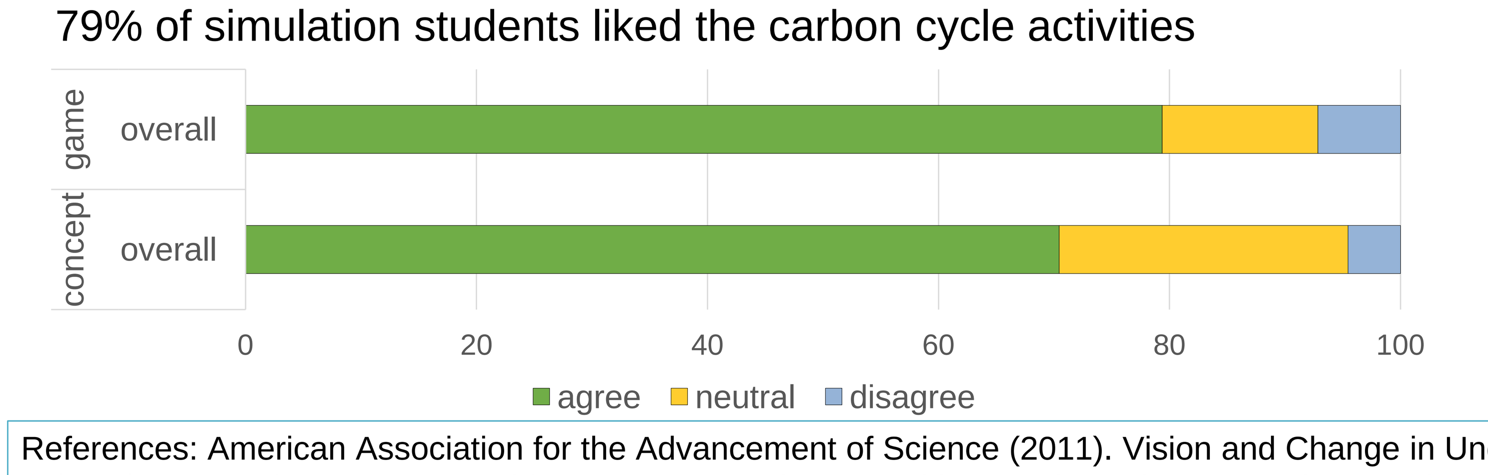
  "Describe how a carbon atom from an old, 'deceased' jackrabbit buried under a cactus can end up within the coyote. NOTE: the coyote does not dig up and consume any part of the jackrabbit's remains"

Student Engagement Survey

For the student engagement survey, overall 90% of concept-map and 87% of simulation students liked the food web activities



For the student engagement survey, overall 70% of concept-map and 79% of simulation students liked the carbon cycle activities



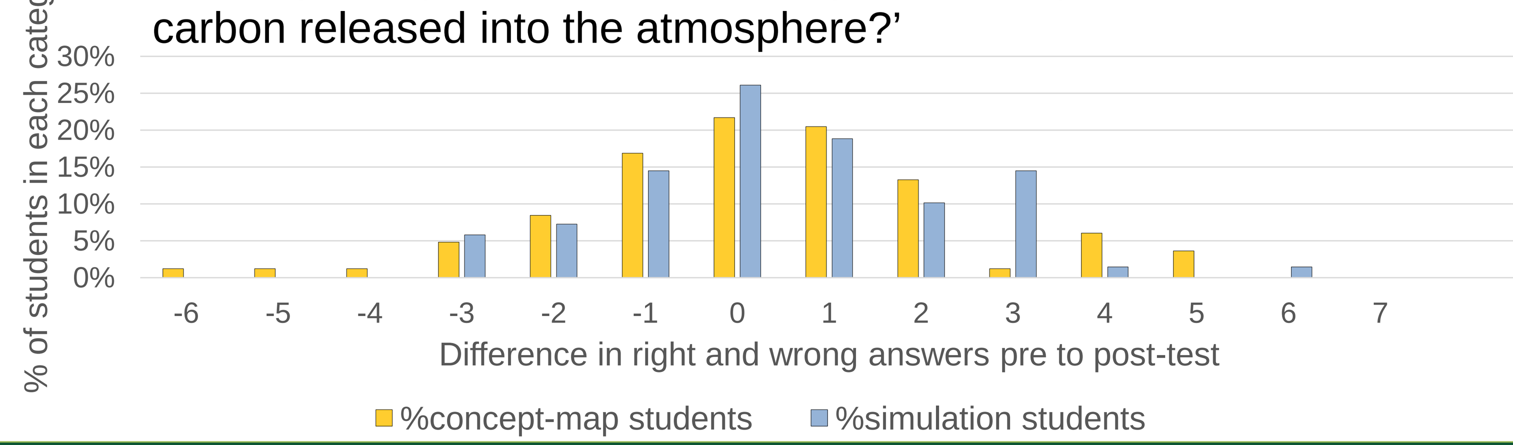
Student Engagement Survey

Top three student categories for "What was helpful?" for each activity							
Concept-map				**Game Simulation**			
Food Web		**Carbon Cycle**		**Food Web**		**Carbon Cycle**	
Visual aid	29%	Explanation TA gives of the carbon cycle	17%	Visuals with graph	33%	Explanation on worksheet or by TA	21%
Hands-on and interactive	21%	Visual aid	17%	The food chain example	18%	Specific carbon cycle examples	14%
The changes in population size	15%	Interactive	11%	"Nothing"	12%	"Nothing"	14%

Top three student categories for "What was confusing?" for each activity							
Concept-map				**Game Simulation**			
Food web		**Carbon Cycle**		**Food web**		**Carbon Cycle**	
"Nothing"	34%	Different sizes of the cards	25%	"Nothing"	69%	"Nothing"	58%
Background information on animal species	30%	"Nothing"	23%	Reading the graph and the variables	8%	Following the rounds of the cycle	10%
Introduction of invasive species	9%	Background knowledge of carbon cycle	13%	Real life vs. model	5%	The length of the activity	10%

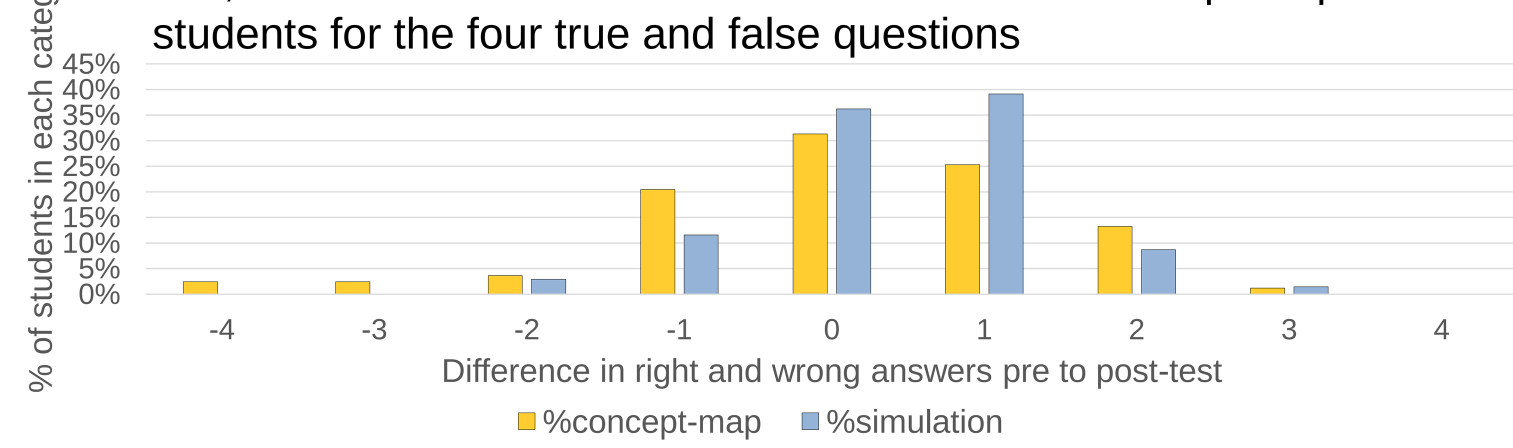
Pre and post-test analysis

Concept-map and simulation students both showed improvements in their pre to post-test for the multiple choice question "How does carbon released into the atmosphere?'



Multiple choice		
Significant increase pre to post-test (paired t-test) for all students	$mean_{pre}$ = 4.86±1.6 $mean_{post}$ = 5.23±1.6	p<.05
No significant difference between concept-map and simulation students (t-test)	$mean\Delta_{concept}$ = 0.27±2.1 $mean\Delta_{simulation}$ = 0.51±1.8	p=.474

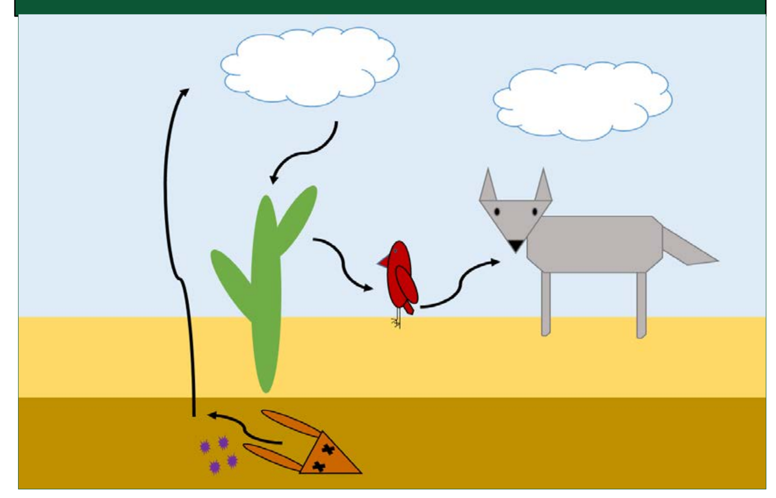
Concept-map and simulation students overall did better pre to post-test, and simulation students did better than the concept-map students for the four true and false questions



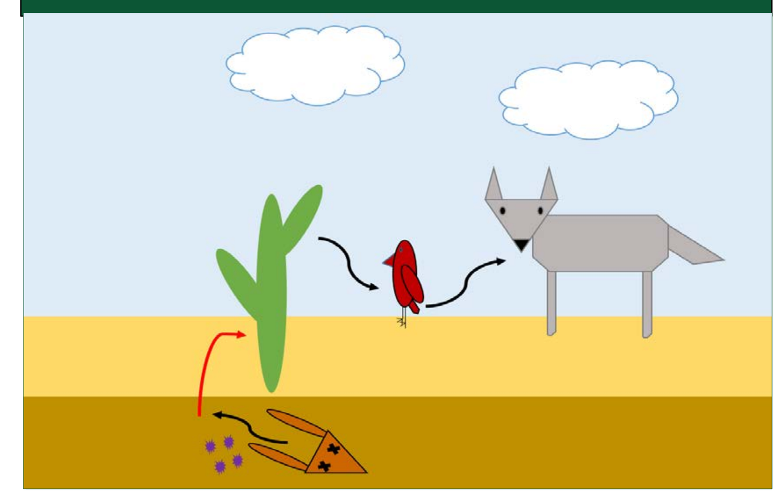
True False		
Significant increase from pre to post-test (paired t-test) for all students	$mean_{pre}$ = 2.06±1.0 $mean_{post}$ = 2.32± 1.0	p<0.05
Trend for simulation group towards improvement from pre to post-test (t-test).	$mean\Delta_{concept}$ = 0.11±1.4; $mean\Delta_{simulation}$ =0 .43±1.0	p=.059

Student mental models of carbon cycling

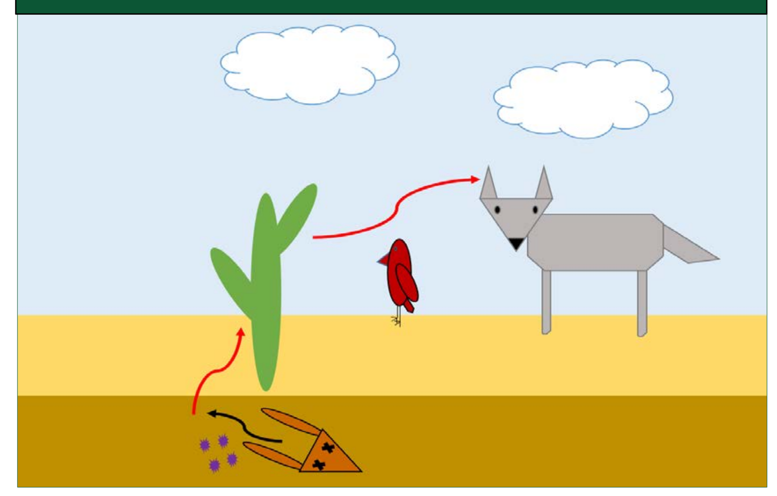
Correct model of carbon cycling
Concept-Map: 1% Simulation 0%



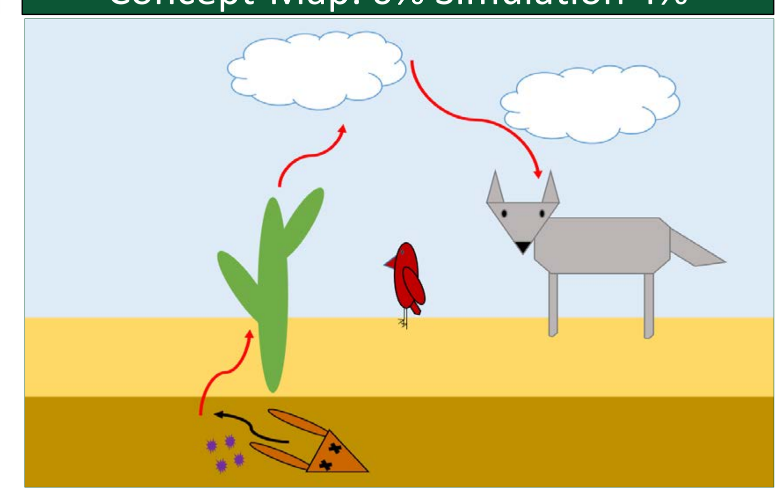
First incorrect pathway: carbon moves from the soil to the cactus passing the atmosphere and photosynthesis
Concept-Map 19% Simulation 17%



Second incorrect pathway: carbon moves from the cactus to the coyote by-passing the herbivore and atmosphere
Concept-Map 11% Simulation 16%



Third incorrect pathway: carbon moves to the coyote from the atmosphere, coming from the soil to the cactus and the cactus to atmosphere, by-passing the herbivore.
Concept-Map: 0% Simulation 4%



Student response categories for steps during carbon cycling

Correct Ideas	Concept-map Students	Simulation Students
Jackrabbit to soil or nutrients	36%	40%
Decomposers	45%	43%
Soil to the atmosphere	6%	10%
Atmosphere to the cactus	5%	6%
Cactus to herbivore	35%	32%
Herbivore to coyote	41%	34%
Incorrect Ideas		
Soil to cactus	42%	50%
Cactus to coyote	25%	28%
Atmosphere to coyote	12%	16%
Cactus to atmosphere	6%	9%

Conclusions

- Students are still holding onto some incorrect ideas such as photosynthesis is not the main route for plants to obtain carbon
- With a trend towards higher learning gains and a comparable student enjoyment frequency, simulation activities may be useful for introducing students to matter cycling
- In the future, observing TA influence on these particular activities may shed some light on other factors that help student learning.

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