Environmental Literacy Meeting
Connecting Actions Working Group
May 24. 2006

Overview

Applying fundamental principles…

Structure of systems:

- Macroscopic (food, appliances, plumbing in house, etc.) and large-scale (food, water, waste disposal) engineered systems
- Connections between engineered and natural systems

Constraints on processes:

- Tracing matter through supply chains and waste disposal chains
- Tracing energy through engineered systems

…to processes in coupled human and natural systems

- Hamburger supply chain
- Paper cup waste disposal chain
- Global warming

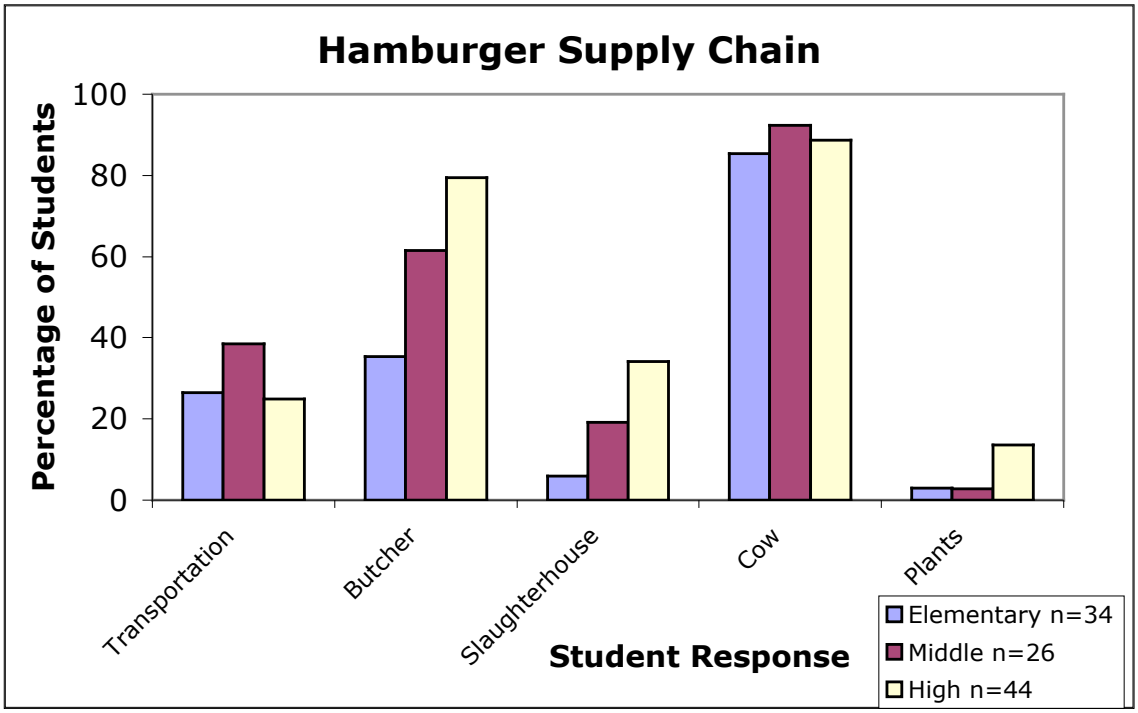
This strand focuses on a particular class of human actions: Our actions as consumers of essential goods and services, including food, clothing, shelter, air, water, and transportation.

Key points of Connecting Actions working group

- We are consumers of essential goods and services, including food, clothing, shelter, air, water, and transportation.
- Goods and services in each of these categories pass through a number of environmental systems on their way to us (the supply chain) and go through additional systems after we are done with them (waste disposal).
- The human systems that supply all of our essential goods and services begin and end in the earth's natural systems.

The goal of this strand is to find out more about student understanding of the connection between human engineered systems and natural systems. This is essential in order to help them develop model-based reasoning about supply and waste disposal chains, which requires that students be able to trace matter and energy through these chains and make connections between them. Through understanding supply and waste disposal chains, students can begin to examine human ecological footprints, how they can have a greater or lesser impact on the environment based on decisions that they make with regards to supply and waste disposal chains, and realize that individual and societal decisions make a difference.

Question 1: You go through the lunch line at school and see that they are serving hamburgers. Where did the hamburgers come from?



*No mention of feedlots
**This figure includes a few, but not all of student responses.

Table 1. Percentage of Student Responses of Steps in Hamburger Supply Chain

Code	Elementary (%) n=34	Middle (%) n=26	High (%) n=44	Total (%) n=104
Package	14.7	23.1	22.7	20.2
Visible storage	76.5	61.5	79.5	74.0
Transportation	26.5	38.5	25.0	28.8
Meat processing/butcher	35.3	61.5	79.5	60.6
Slaughterhouse	5.9	19.2	34.1	21.2
Farm	29.4	50.0	68.2	51.0
Cow	85.3	92.3	88.6	88.5
Parent	14.7	34.6	15.9	20.2
Growth	29.4	46.2	27.3	32.7
Plants (i.e., food for cows)	2.9	2.8	13.6	7.7
Other*	14.7	7.7	22.7	16.3

Responses were coded as **other when they did not fit into one of the other codes and there were not enough similar responses to constitute creating a code.*
supply chain. They

Trends:

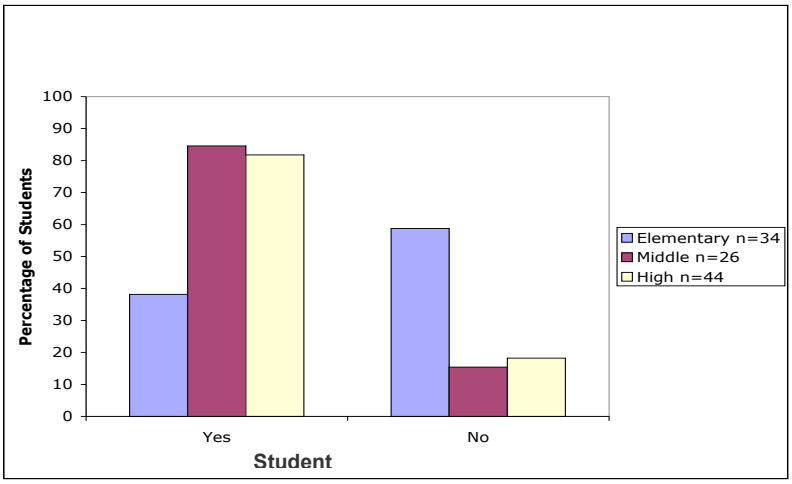
- Student tend to describe events and locations, rather than trace matter and energy
- The supply chains students describe depict stereotypical small-scale rural meat production, rather than large-scale mass production
- Few students traced matter across connections to natural systems
- High school students **mention more steps** in both the hamburger supply chain and paper cup waste disposal chain than middle school or elementary school students.

Question 2A: Do you think that there could be any connection between the meat in your hamburger and a corn field in Iowa?

-Most high school and middle school students think that there **IS** a connection between hamburger meat and a corn field

-Most elementary students think that there **IS NOT** a connection

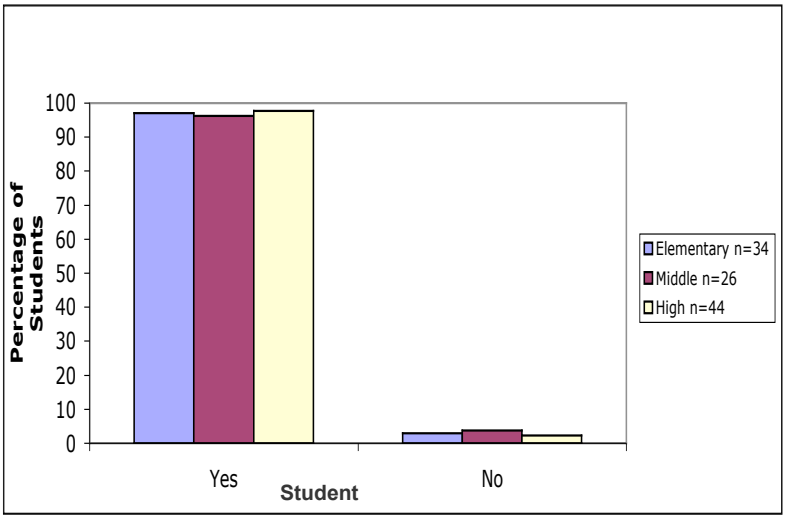
Connection between hamburger meat and a corn field



Question 3A: You drink some water from a paper cup from the school cafeteria. Do you think there could be any connections between the paper cup and a tree?

-Almost all students think there **IS** a connection between a paper cup and a tree

Connection between paper cup and tree



Question 2B: Explain why you think hamburger and corn could or could not be connected

Table 2. Percentage of student responses to why hamburger and corn could or could not be connected

2A response	Code	Characteristics of student answers	Elem. (%) n=34	Middle (%) n=26	High (%) n=44	Total (%) n= 104
Yes	A	Yes – mentions ***why*** cows might eat corn; specifically relate eating corn to growth of cow	0	3.8	4.5	2.9
Yes	B	Yes – cows eat corn, but **do not** mention *why*	2.9	**46.2**	**52.3**	34.6
Yes	C	Yes – cows on same farm, but no connection between cows eating corn or both cows are raised on farms and corn is grown on farms	**20.6**	15.4	13.6	16.3
No	D	No – corn is not the same thing as meat	**38.2**	3.8	13.6	19.2
No	E	No – no relationship; states that there isn't a relationship, but doesn't give any further explanation as to why	2.9	0.0	2.3	1.9
No	F	No	0.0	7.7	2.3	2.9
Yes/ No	G	No response	2.9	0.0	0.0	1.0
Yes/ No	H	Unintelligible/illegible/answer does not make sense	20.6	3.8	0.0	7.7
Yes/ No	I	Other	11.8	23.1	15.9	16.3

Responses were coded as **other when they did not fit into one of the other codes and there were not enough similar responses to constitute creating a code.*

Question 3B. You drink some water from a paper cup from the school cafeteria. Do you think there could be any connections between the paper cup and a tree?

Table 2. Percentage of student responses to why a paper cup and a tree could or could not be connected

Code	Response	Elem. (%) n=34	Middle (%) n=26	High (%) n=44	Total (%) n=104
A	Yes – mentions **pulp** or a **process**	0.0	0.0	**11.4**	4.8
B	Yes – specifically mentions the **wood** of the tree, does not mention a process	0.0	**15.4**	4.5	5.8
C	Yes – paper made from trees - does not mention wood or process	**79.4**	**57.7**	**70.5**	70.2
D	Yes – no additional information given other than because it is	0.0	7.7	0.0	1.9

	paper				
*					
F	No – no connection	2.9	3.8	0.0	1.9
G	No response	0.0	0.0	0.0	0.0
H	Unintelligible/illegible	2.9	7.7	0.0	2.9
I	Other	14.7	7.7	13.6	12.5

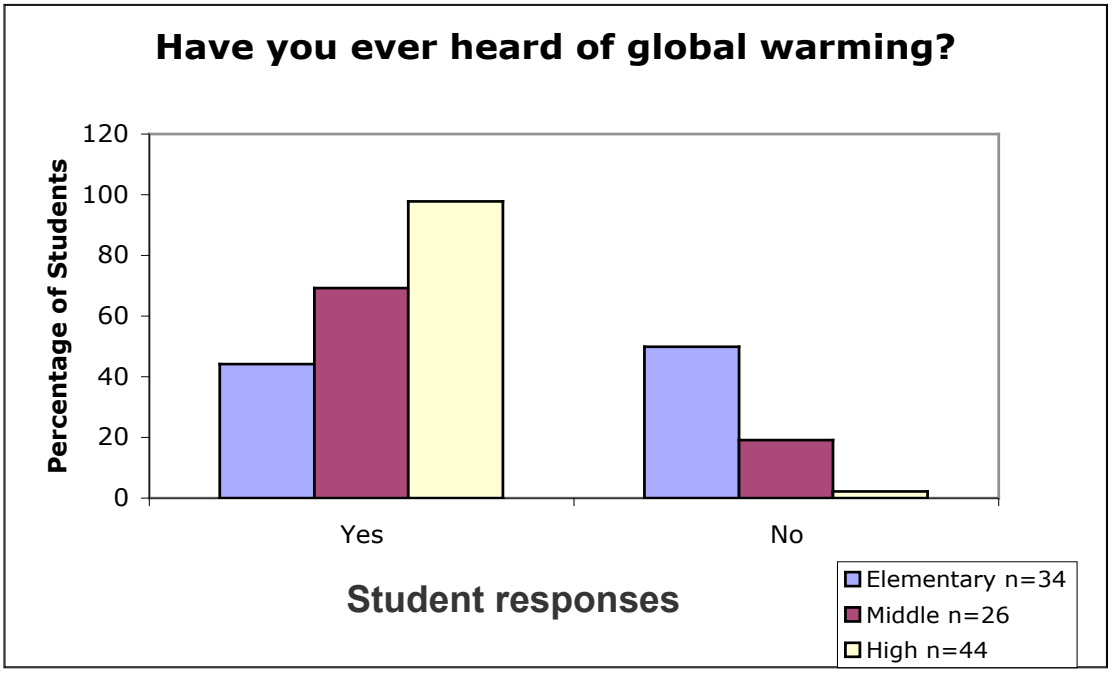
Responses were coded as **other when they did not fit into one of the other codes and there were not enough similar responses to constitute creating a code.*
***Originally from the pilot study, there was a code E, but this code was eliminated because no student responses fit this code.*

Trends for Questions 2 & 3:

- Increasing awareness of connections
- High school students give more detailed explanations for connections between hamburger meat and corn fields and paper cups and trees (e.g., some mention transformation of matter)

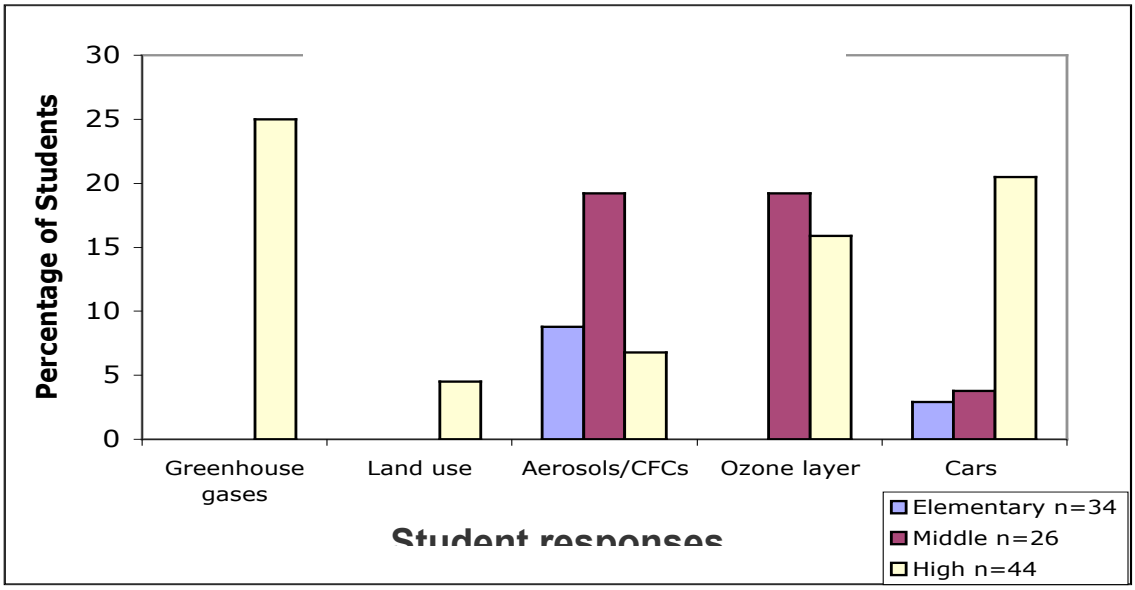
Question 6:

6A. Have you ever heard of global warming (also called global climate change)?

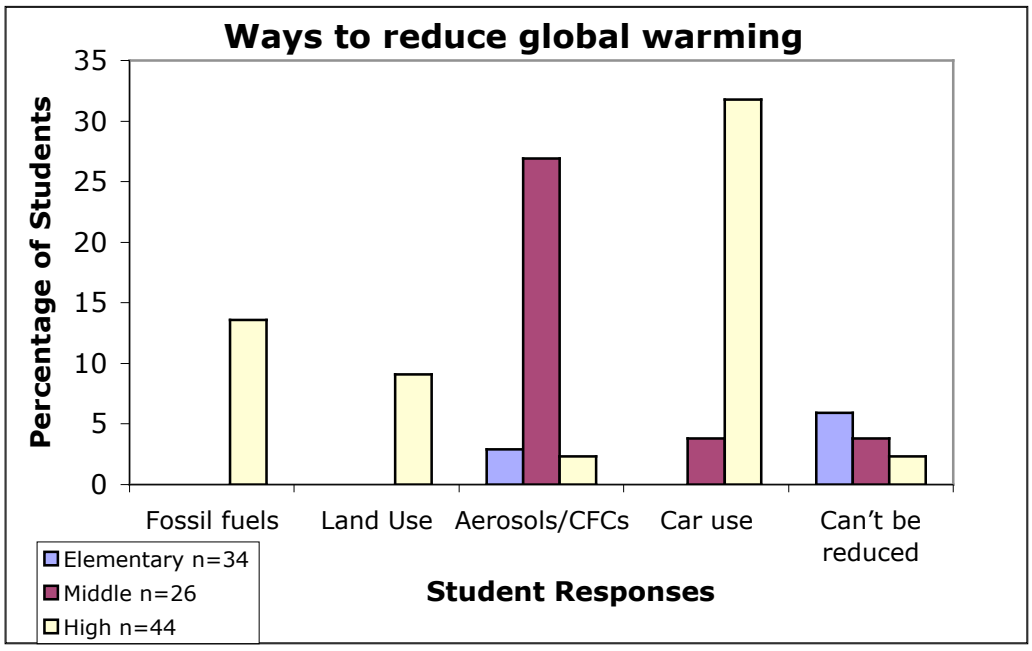


- Most middle and high school students **HAVE** heard of global warming
- Most elementary students **HAVE NOT** heard of global warming

6B. What do you think causes global warming/global climate change?



6C. How do you think global warming/global climate change can be reduced?



Trends for 6B and 6C:

Students mention origins or by-products, but not processes, thus students do not connect human-engineered systems to natural systems

Key Findings

- **Actors and location/places.** Students generally depicted supply and waste disposal chains in terms of actors and location/places. The number of steps (actors and places) mentioned in supply and waste disposal chains is significantly associated to school level (elementary, middle, and high). Elementary school students mentioned the fewest steps and high school students mentioned the most steps when tracing supply and waste disposal chains.
- **Tracing matter and energy.** Students mentioned matter more often than they mentioned energy. When students did mention energy, it was high school students, as opposed to elementary school students. Students of all ages failed to recognize the role of energy consumption in supply chains and waste disposal chains. For example, only 6.8% of the high school students (and none of the elementary or middle school students) mentioned energy to heat the hot water as an environmental impact of handwashing dishes.
- **Processes/Transformation of matter and energy.** In general, more high school students mentioned some type of *transformation of matter*. In the paper cup recycling waste disposal chain, more high school students than middle or elementary school students mentioned some process that the paper cup undergoes in order to be recycled and made into a new product. When explaining the possible connection between hamburger meat and a corn field, a small percentage of high school and middle school students mentioned that cows eat corn in order to grow, while no elementary school students gave this reason. Elementary students who saw a connection explained that cows and corn exist on the same farm; they did not mention that cows may eat corn. In their rationales for the connection between a tree and a paper cup, only high school students mentioned some process that the tree had to go through in order for paper to be made.
- **Connections between human and natural systems.** In part because they were describing sequences of locations and events rather than transformations in matter and energy, students were generally vague about how human supply chains and waste disposal chains were connected with natural environmental systems.
- **Infrastructure and by-products.** Systems and processes require infrastructure that connects various steps or stages of the systems and processes. While more middle school than elementary or high school students mentioned transportation, a form of infrastructure that connects steps, in the hamburger supply chain, more high school than elementary or middle school students mentioned transportation in the paper cup waste disposal chain. Therefore, it is difficult to determine if high school students recognize infrastructure more often than elementary or middle school students from this data. In the dish washing question, more high school students mentioned an impact that using resources has on the environment. One way to view impact on environment is in terms of the by-products that the dish washing process creates. Elementary school students most often mentioned that using resources had no impact on the environment. (Elementary students may have had trouble understanding the question due to the difficulty of its wording. They may not have known what *resources* and *impact* meant.)