LEARNING TO FOCUS ON PROCESSES AND STEADY STATES IN ECOSYSTEMS DYNAMICS USING A VIRTUAL ENVIRONMENT

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ABSTRACT

Reasoning about ecosystems as scientists do involves considering the complex causal dynamics in terms of processes and steady states (e.g. Walker & Salt, 2006) as opposed to focusing on particular events. But students often bring limiting assumptions to their reasoning about ecosystems (e.g. Grotzer & Basca, 2003; Hmelo-Silver, Pfeffer, & Malhotra, 2003) and to steady states and processes in particular (e.g. Chi, 1997; 2005). This paper considers promising shifts in student reasoning about the nature of steady states and processes in ecosystems dynamics as they used a virtual environment with affordances designed to help them learn to reason about steady states and processes. It considers an intermediate level approach that students adopted and whether it may be facilitative or limiting.

OBJECTIVES

Reasoning about ecosystems involves thinking about the complex causal dynamics in terms of processes and steady states as opposed to focusing on particular events. But research has demonstrated that students often bring a limiting assumptions to their reasoning about ecosystems (e.g. Grotzer & Basca, 2003; Hmelo-Silver, Pfeffer, & Malhotra, 2003)—ones that differ substantially from those of ecosystems scientists (e.g. Walker & Salt, 2006). Chi and colleagues have argued that students often reduce steady states and processes to events (Chi, 2005; Ferrari & Chi, 1998). This paper considers shifts in student reasoning about the nature of steady states and processes in ecosystems dynamics as they used a virtual environment with affordances designed to help them learn to reason in more expert ways about these concepts.

THEORETICAL BACKGROUND

Our everyday notions of causality tend to be event-like (Grotzer, in press). The characterization is fundamental to how many philosophers and causal theorists define causes and effects (Sloman, 2005). However, it departs from how ecosystem scientists typically construe causal systems, which includes reasoning about processes and what are referred to as “pulse” and “press” disturbances to balance and flux over time in a resilience model. Pulse disturbances refer to short-term oscillations where the system undergoes sudden changes and may or may not return to the earlier state and press disturbances refer to continuous disturbances that result in more permanent change (Bender, Case, & Gilpin, 1984). Both are characterized more by shifts in dynamic than by events.

Chi and colleagues (1997; 2005; Ferrari & Chi, 1998) have argued that students often assign the wrong “ontological status” to concepts, for instance, treating processes as event-like. She distinguishes between events and equilibration, arguing that events often have distinct actions with a beginning, middle, and an end. These actions are often contingent or causal, and that they unfold in a sequential order. Events are “goal-directed’ and are completed when the goal is achieved. In contrast, equilibration often involves many actions occurring at once. The actions can be random and independent and they have a net effect at a systems level. A continuous dynamic is in play.

Reasoning effectively about processes and steady states in ecosystems dynamics also entails reasoning about delays, extended time scales (Dodick & Orion, 2003a, 2003b) and understanding the relevance of particular time scales to particular issues (Grotzer, 2010).. How students reason about changes over time, equilibrium, steady states and processes relate to understanding the dynamics of energy transfer, matter recycling, and the interaction between biotic and abiotic factors.

Dede and colleagues (Dede, 2009) have designed and investigated Multi-User Virtual Environments or MUVEs. These 3-d worlds invite students into a simulated immersive experience and offer affordances that the real world cannot. Dede has found that learning in MUVEs can result in increased students engagement and self-efficacy (Ketelhut, 2007; Nelson, 2007; Clarke & Dede, 2009; Ketelhut et al, 2010). Dede (2009) argues that extended, interactive experiences such as those enabled by MUVES are necessary for learning complex processes. EcoMUVE is a MUVE designed to offer affordances to students to help them to learn about the complex dynamics within ecosystems (Metcalf, Dede, Grotzer & Kamarainen, 2010; Metcalf, Kamarainen, Tutwiler, Grotzer, & Dede, 2011). This paper considers how EcoMUVE may have impacted students' focus on steady state versus process-oriented explanations.

METHODS

Seventh and eighth grade students (n = 81) in three middle school classes participated in the study. They were introduced to the EcoMUVE Pond Module at the beginning of the week and given an opportunity to explore it. After an ecological change is discovered, students were given a written assessment which asked them to offer their initial insights into what might be going on and what patterns of inquiry they might undertake in order to ascertain what happened. Students worked within the EcoMUVE for two weeks and then were given a parallel written assessment.


Figure 1. Screen Shot of EcoMUVE

In the pond module (Figure 1), students explore a pond ecosystem, seeing realistic organisms and collecting water, weather, and population data. Students visit the pond over a number of virtual "days." During the time period simulated by the EcoMUVE, changes begin occurring within the pond. These changes are subtle, but detectable both visually and through measurements of water quality. Eventually, these changes result in an event—the large fish in the pond die overnight. Known as a fishkill, it may be viewed as part of a larger process in play or as an event that grabs ones' attention and requires explanation. The changes result from complex interactions as follows.

Runoff from housing developments carries fertilizer to the pond. The phosphorus and nitrogen in the fertilizer support algae growth. As levels of phosphate lessen, the algae population lessens and dead algae accumulate on the bottom of the pond. Bacteria, the dominant decomposers in aquatic ecosystems, consume the dead algae and the bacteria population increases. During decomposition, the bacteria use up a lot of the oxygen in the pond. Eventually, there is not enough oxygen produced during photosynthesis during one virtual day to support the amount of oxygen used during respiration that night. Dissolved oxygen concentrations in the pond became very low overnight, leading to the death of the large fish in the pond from inadequate oxygen.

In order to solve the mystery, students must attend to changes over time in addition to recognizing the role of non-obvious causes and that human actions outside of the pond affect the pond ecosystem. This involves sustained attention to that system. Based on the existing research, it was our expectation that subtly occurring changes in the EcoMUVE would not be detected until the fishkill event grabbed the students' attention.

The following affordances for recognizing change over time and process-oriented versus event-based causality are built into EcoMUVE. A time-traveling calendar tool allows them to go back and forth in time. They may talk to residents or collect data and clues. Data they've collected is stored in a data table so that they can analyze temporal trends using a built-in graphing function. (Figure 2). There are visual changes over time, like the color of the pond. (Figure 3). Subtle changes are occurring well before the fish kill that signal something is changing. Prior to the actual fish kill, fish are beginning to swim closer to the surface of the pond and begin taking gasps of oxygen from the pond's surface.

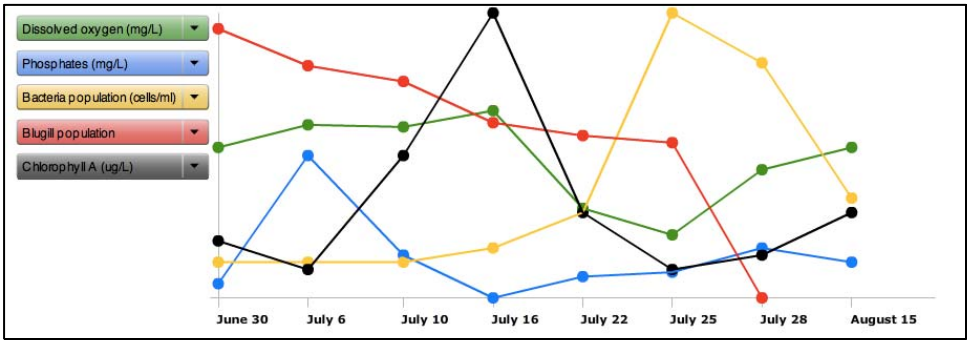

Figure 2: Graph of Data Over Time

Figure 3: Visual Changes in Turbidity of the Pond on Different Days

DATA SOURCES AND SCORING

The pre and post-assessments were designed to be open-ended to allow students to structure their responses. Students were given five spaces to report their ideas about possible causes of what was happening. Students were then asked to list as many ideas as they could about how they might figure out what was going on. These written assessments yielded quantitative and qualitative results as reported below. In addition, emergent coding of classroom videotape was conducted on the conversations in the classrooms of two teachers who were deemed high fidelity in carrying out the EcoMUVE module. These teachers taught the entire module and were recommended by their administration as being capable science teachers.

The student data were scored blind for pre- or post-assessment. Two independent coders scored the data until they reached between 85% and 95% agreement with one coder coding 100% of the data and the other coding 25%. Remaining cases were discussed until agreement was reached.

Responses were coded in an etic process as follows. "Event-based causality" explanations (EBC) focused on specific moments in time when something happens. Examples of event-based causes include "a sewage spill leaked into the pond" or "a truck dumped dirt with poisons into the pond." Processes or steady state (PSS) phenomenon refer to dynamics that are on-going over time. For instance, balance of populations, or a disease that is introduced to the fishes and slowly kills some and not others leading eventually to a fitter population. Comments that address balance and imbalance, and changes to those levels are considered process or steady state explanations. A PSS focus does not rule out comments about events, it just puts it in a different context. For instance, "the balance of predators to prey was disrupted" focuses on the dynamic over time and how disruptions interact with that dynamic. Attention was paid to students' exact wording. The scoring did not hinge upon the adequacy of the explanation, but on how the students framed the causal features.

A bottom-up coding process was also conducted to reveal any emergent patterns in students' responses. This analysis was conducted by two individual coders who then met, discussed their results, and reported upon overlapping categories. A similar bottom-up coding analysis was carried out on videotapes of class discussions in the two teachers' classrooms. These tapes included conversation about what explanations students had developed for understanding the ecosystem dynamics and reasons for the fish kill.

RESULTS

On the initial assessment, as expected, students gave significantly more event-based explanations than process and steady state explanations (Event-based: $M = 2.72$ ($SD = 1.50$); Processes and Steady States: $M = 1.41$ ($SD = 1.31$) (Mean difference = 1.31, $t(77) = 4.47$, $p < .0001$). They tended to focus on "what happened" as opposed to "what was happening." Students talked "finding out what was happening on the days before" (s164); "what happened in the last few days?" (s117).

No significant difference was found between steady state and process-based responses on the post-test (Event-based: $M = 1.89$, ($SD = 1.49$); Processes and Steady States: $M = 1.49$, ($SD = 1.66$), Mean difference = .40 $t(78) = 1.25$, $p > .05$). Students gave significantly fewer event-based responses on the post-test as compared to the pretest (mean difference = .83 ($t(75) = 3.75$, $p < .0003$). While this is a positive outcome, note that students did not produce significantly more process and steady state responses on the post than pre-test. Their answers were less broad in the sense of brainstorming and more focused on their explanations.

The emergent coding suggests a few reasons why this might be so. Students may have ruled out certain explanations while studying the data in the EcoMUVE. However, for some students the ways that they worded process and steady-state language did not fall straightforwardly into either category and suggests a potential intermediate model for students. Some students clearly adopted more process language. On the post-test, students mentioned wanting to find out the population levels: "too little phosphates; too little oxygen, population change in organisms in food chain, amount of algae in the food chain changes." (s135) This student talked about needing to monitor the amount of oxygen, phosphates, etc. in the water everyday. Some answers were mixed: "food chain broke; limiting resources; not enough oxygen." (s128)

However, some students gave explanations that focused on long causal chains of events between the fertilizer and the fish kill (characterized by a sequential unfolding as found by Chi for event-based processes). Interestingly, students who had learned a lot about the scientific explanation by the post-test often retained "event-based wording"—viewing it as something "that happened." Many of these were in the form of linear, domino-like narratives. For instance:

> "The fertilizer run-off went into the stream and then into the pond and then pond, the algae grew a ton. Bacteria thrived. When fertilizer wore off, algae stopped growing. With all the CO2 released from the decomposition of the algae, the fish went back to their maker. (s167)

This language may be a necessary step, functioning as a facilitative, intermediate model or it may function as a limiting model that retains the "event-based" ontology and limits shifts towards more expert thinking. Further, the source of the pattern bears investigation. Students may have framed the information as a linear narrative as found elsewhere (Driver, Guesne, & Tiberghien, 1985; Grotzer & Basca, 2003; Raia, 2008). Alternatively or perhaps additively, classroom discourse may have introduced and/or reinforced the pattern.

The analysis of classroom video suggests that this may be at least one source of the reasoning pattern. We found many examples where the teachers' language summarized the EcoMUVE into a linear narrative. For example:

> “So we had fertilizer as our first point. And I know that a lot of, how many groups started with fertilizer as the beginning of that story. A lot of groups did. “
> "Less sunlight, right And if there’s less sunlight then what happens [pause]? What happens in the water if there’s less sunlight that’s able to reach the pond?"

We also heard clear “Process statements” from the teachers:

> “Chlorophyll. So our chlorophyll increased. So the algae, an increase in the algae population made it increase. And then what happened? Not only was it green, but it was cloudy….Alright. How many groups had this part of the story? I know a lot did in this class. At this point we had chlorophyll increasing and turbidity increasing. Yeah… Did the turbidity just increase because or did it have something to do with the algae? Right is the turbidity increasing a separate factor or does it have something to do with the algae? Or maybe someone could answer that. So the chlorophyll increased because of the algae, but what about the turbidity? When we write our summaries? What do you think?”
> “That’s that’s a good main line for the story, but we’ve got some other things going on. What are some other variables that we noticed? [pause] Let’s see. Did anything happen with the water temperature?”
> “The oxygen can not get into the water, so not only is there increased water temperature, but there’s increased air temperature [pause] and there is no wind on that day.”

Other instances did not fall neatly into one category or the other:

> T: Hmmm, what did the turbidity cause? Having a high turbidity of water, what did it cause? Any idea?
> G: Well actually the turbidity it went up, when the fish were going down, the fish population was going down[L1] .

It is important to note that given how highly linear our language is, it is not necessarily easy to not frame at least some of the EcoMUVE patterns linearly. However, it is also clear that the EcoMUVE supporting materials can be designed to help teachers differentiate between these kinds of language. One of the teachers used a language arts rubric for writing summaries when assigning the class to write their summary of EcoMUVE, and part of that requirement is to organize the summary in a linear fashion (T2: 35:26). Helping teachers and students to differentiate between these two reasoning patterns should be helpful. Whether that will be enough to overcome what may be strong linear narrative tendencies is an empirical question and provides direction for future classroom research on EcoMUVE.

SIGNIFICANCE

The shift towards reasoning about processes over steady states is important for understanding the causal dynamics of ecosystems and for living sustainably in the world. Our findings suggest areas of promise in helping students to learn these challenging concepts. However, they also illustrate the complexity of the endeavor and that the difference between helping students to hold more or less expert views can be in the details. The findings hold implications for designing effective instruction in helping students develop deep understanding of these important ecosystems concepts.

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APPENDIX:

11/28/11
G block; T2
T= Teacher
TA= Teacher Assistant
Transcribed from VN620116

Codes:
Process
Linear

00:08

T: [To the class] Ok, so I'm looking to see what responses people are putting to the warm up, which is, did the fertilizer directly cause the death of the fish, why or why not? I'm looking around for some interesting ideas. Please keep your notebooks open.

[pause- as she's looking around]

00:49
T: [to a student] Explain more, but I like your idea. Yep.

00:58

T: [to a student] And what would the plants do then? How would it help the plants?

G: Because it would create like algae… [speaks too quietly].

T: There we go, that's what I was looking for.

[pause]

1:52

T: About 30 more seconds. Yep. [student talking quietly in background] I'll answer that question a little bit later. Hmmm. Explain more. Tell me why. This will help you, with the answer.

2:21

T: Alright. What I'd like you to do right now is, tell your partner what you are thinking about this warm up question. Turn to your partner, and tell them what you wrote or what you were thinking about.

[students begin talking in background difficult to distinguish conversations]

3:35

T: Alright. What are some ideas? What are some ideas that we have? Let's have all attention up front. Let's see, what are some ideas that you can contribute that will help us remind each other of what was the big story. We are going to go over the big story today about solving the mystery. But let's remind each other about what happened before break. What are some ideas about this fertilizer question? M, start us off.

B: I said no, because it's like the world health organization because it caused something that caused a chain reaction.

4:08

T: So it caused, so you said no, it caused a chain reaction? OK. Alright. Let's build on that idea. J, what do you think?

G: I don't think the fertilizer directly caused the fish's death because without the rain the fertilizer wouldn't get into the pond.

T: So the rain was an issue. Without the rain, it couldn't have gone to the pond. Ok. R, you have an idea?

G: What about the lack of oxygen?

T: Sorry?

G: The lack of oxygen?

T: So you said the lack of oxygen. What about it?

G: [too quiet]

T: So, are you saying here that the lack of oxygen was the issue, not the fertilizer? Was directly the issue?

5:04

T: Ok, so lack of oxygen is more likely the direct issue according to R. Yes, L?

G: [too quiet]

T: pH would have been a concern. So when you're looking at pH, when you were looking at the graphs, and you saw that it did not change. Ok, so you're looking at graph levels. Any other ideas we'd like to contribute? Hmm? How many..

TA: [interrupting] One question I saw on some notebooks was, is fertizer a bacteria?

T: Oh.

TA: Could we think about that as a class? Is fertilizer a bacteria? Why or why not?

6:00

T: What is fertilizer? What did we learn from the learning quests? What is fertilizer? J, what is fertilizer?

G: Isn't fertilizer like phosphates and nitrates that helps plants grow?

T: Ok. So fertilizer is made of phosphates and nitrates. And phosphates and nitrates what are they? What are they made out of? B, I need you to either raise your hand or contribute to this class discussion. I am asking what did we learn in our tracker about phosphates and nitrates were made of? What are those things? Yeah the molecules. And what are the molecules made of? L?

G: Atoms.

06:56

T: Atoms! So these are molecules made up of atoms and are they, are those things alive? Phosphates and nitrates? Are those things alive?

B: [inaudible]

T: No, these are not alive. Is bacteria alive?

B: Yes.

T: Yeah, more so than molecules and atoms. I mean everything is made up of molecules and atoms, but bacteria is atoms made just the right way to make a living thing.

TA: Ok, then, so fertilizer is not bacteria?

T: Correct, but both have a very important role in our situation. Alright, so we have some interesting ideas here. Alright, so what I'd like to do right now is, um. You guys have your notes out, and this is going to be very important. I'm going to be going over, um, with you the whole story of EcoMUVE.

07:58

T: And what I'd like for you to do, is while you are following along and adding information that you think is important to our class discussion, it would be very helpful to you, to write down any facts that you think are very important, because what's going to happen after that is that we're going to be writing a summary about the whole mystery, because I want to see what you remember from the entire mystery and we're going to be writing a summary. You'll be able to use your notebooks and your EcoMUVE papers and anything that you need, but it would be very useful if you wanted to write down important things that we're talking about. Important concepts, so you'll have your notebooks right there.

08:46

T: Alrighty. So here we are. In EcoMUVE we had lots of different variables that we looked at. Lots of different variables that we looked at from water temperature to turbidity to bacteria, and things that were alive, which are called what kinds of factors?

Class: [quietly] biotic

T: Biotic, and not alive, which are?

Class: [quietly] abiotic.

T: Abiotic. Oh there it is, it's over there. Ok. So in our story at first the fish were alive, true?

Class: Yes

T: Yes. And at the beginning of the story, it starts with our warm up, we know that fertilizer was an issue, true?

Class: uh hmm

T: So we had fertilizer as our first point. And I know that a lot of, how many groups started with fertilizer as the beginning of that story. A lot of groups did.

09:48

T: We know that fertilizer, we just said were made of phosphates and nitrates, true? Woops, I didn't spell that right. Phosphates and nitrates that as J said helps plants grow, so I'm going to connect these together. That helps plants grow. In his case it was intended to make the grass grow, that's why they applied it to the grass, right? But instead, what happened in our story? [pause] What happened to our story instead? It didn't go into the grass because?

B: It rained [to quiet to hear the rest]

T: because, sorry?

B: It rained.

T: It rained. So, then it rained which, um, transported the fertilizer to the?

Class: pond

10:48

T: Pond. So then the fertilizer, because of the rain, I'm going to move this up here, actually. Because of the rain the fertilizer into the pond. Alright, and instead of making the grass grow, it instead made, what grow?

Class: Algae

T: Algae. And I can see that because when we go into our graph, we view data

B: It's there.

T: Oh thank you. Show graph. I appreciate that. Um, if we looked at the blue green population, blue algae and blue-green algae and green algae populations we noticed that they went up after it rained. What day did it rain?

11:49

Class: [inaudible]

T: On the 6th. I believe it was the second day it rained. Notice the high cloud cover on July 6th, , right? How come when it rained it didn't automatically make the algae grow? Why wasn't the algae also high on that day? It rained, the algae should have been growing crazy on July 6th. How come that didn't that happen? What have we got? L?

G: [inaudible]

T: I'm sorry?

G: The fertilizer needed time to work.

T: The fertilizer needed time to work, yeah. It needed time to get down to the pond, it had to be absorbed by the algae, and then they grew. Notice as, after the rain, it's growing and growing and growing and growing and growing. Alright, so now the algae population flourished. What does flourished mean again?

12:55

Class: [inaudible]

T: Increased, like the rats right? The Who. So then, the algae increased and what happened to the water?

Class: [inaudible]

T: It got all green, right? So, then why is it green? What's it called when it's green? What's that pigment called? A?

G: [inaudible]

T: Chlorophyll. So our chlorophyll increased. So the algae, an increase in the algae population made it increase. And then what happened? Not only was it green, but it was cloudy. What's that called again? M?

G: Turbidity.

T: Turbidity. Turbidity increased.

13:49

T: Alright. How many groups had this part of the story? I know a lot did in this class. At this point we had chlorophyll increasing and turbidity increasing. Yeah. That sounds familiar. Alright now.

TA: Miss R I have a question.

T: Yeah

TA: Did the turbidity just increase because or did it have something to do with the algae? Right is the turbidity increasing a separate factor or does it have something to do with the algae? Or maybe someone could answer that. So the chlorophyll increased because of the algae, but what about the turbidity? When we write our summaries? What do you think?

14:40

B: The chlorophyll increase causes the turbidity to rise because because [inaudible]

TA: So the chlorophyll

B: [inaudible]

T: The chlorophyll within the?

TA: Within the water?

T: Where is the chlorophyll? Within what organism?

B: Algae.

T: In the algae. So it's very turbid or it's high turbidity because there's more algae organisms. There's more of these algae's in the water than there were before so they're clouding the water up. OK. Alright, now because it gets so cloudy, let's look at our evidence again.

15:43

T: We have, what, we're going to put turbidity up here and take off blue green algae. So we have cloud cover and we have, ope, I need turbidity. Hmmm.

G: [inaudible]

T: They are, well remember they're not necessarily the same because they're different variables, right? Because up here they're 20 and there is 30. Well they might be close. Alright, so when we have turbidity, let's take off cloud cover. When we have turbidity up here, we notice that there's high turbidity on this day. What day did the fish die?

Class: [inaudible]

T: Yeah. So did the turbidity cause the fish to die?

Class: No.

T: Hmmm, what did the turbidity cause? Having a high turbidity of water, what did it cause? Any idea?

G: Well actually the turbidity it went up, when the fish were going down, the fish population was going down.

17:01

T: Hmm. Ok, Let's look at the large mouth bass too, right?. So a slight decrease here as well. Something happened here, it was a dramatic decrease

B: Why don't you just check all the variables?

T: I'm sorry B?

B: Why don't you just check all the variables?

T: All the variables? Well I can't put them all up here at once. Let's see. Alright so for turbidity, it was very high that day. Now if we had, what does turbidity cause? From our learning quest what does it cause? M?

17:39

B: Less sunlight.

T: Less sunlight, right And if there's less sunlight then what happens [pause]? What happens in the water if there's less sunlight that's able to reach the pond? B?

B: Plants can't grow.

T: Plants can't grow. Because of what process?

Class: [inaudible]

T: Photosynthesis.

[Private aside to TA]

18:23

T: Ok, because of photosynthesis, then there's the plant, the algae can't grow, and what else can't they produce?

G: oxygen

T: Oxygen. Yeah Nice job, R.

G: dissolved oxygen

T: Yeah, dissolved oxygen to be specific. OK [pause] Ok. And when there's less dissolved, oxygen, what does that affect? It affects the fish because what process are they going through that they need oxygen? The opposite, often thought of as the opposite of photosynthesis, it's what we do. A, what is it?

B: Respiration.

T: Respiration. Taking in oxygen.

19:36

TA: So, in this part here, is there less photosynthesis because there is less sunlight? Or could someone explain this part here in your own words for us? So going from the turbidity down to the photosynthesis? [pause] Can someone explain that for us, if we're going to use that in our written summaries?

T: What does that part mean? [pause] Can someone restate? [pause]

TA: Cause we're going to ask you to restate this in writing, so this might be a good practice.

20:30

[pause]

T: M, can you restate it for us?

B: Sure

T: Thank you. The yellow part

B: [inaudible- too quiet] photosynthesis because of the turbidity so then there was no more [inaudible-too quiet]

T: Ok. That is good. We've got some parts missing too. Yes, T?

G: [inaudible- too quiet]… dissolved oxygen and fish need it.

T: And fish need it for what process?

G: [inaudible]

T: Respiration. Uh hm. Indeed. Good, good. I love that. Nice job. Alright we've got some other variables in here to right?

21:40

T: That's that's a good main line for the story, but we've got some other things going on. What are some other variables that we noticed? [pause] Let's see. Did anything happen with the water temperature? Let's see. Did anything happen to the water temperature, when the fish were dying?

Let’s put that large mouth bass population on there. If you had to say it increased, when did it increase the most?

G: July 25th.

T: Huh, when the fish died, right? What would an increase in water temperature cause? Think about your learning quests. S?

22:32
B: Would it be high turbidity or high pH?

T: It could be. Something else that might happen though, if there’s warm water what does it not have in it? L?

G: Oxygen.

T: Oxygen. So that also causes a lack of oxygen. So we have, what was that again?

Class: warm water

T: So increased water temperature on that day also caused less dissolved oxygen.

23:19

T; What’s another factor? It seems like less dissolved oxygen is a big factor, what’s another factor that changes dissolved oxygen levels? Remember those bowls from the learning quest, one of them was temperature, another had a little fan on it. What could that be? What have we got ? Yes?

G: The temperature.

T: Sorry?

G: The temperature.

T: The temperature of?

G: of the air?

T: The air temperature, definitely. Did we measure that? That would definitely I think it’s in water temperature too, no? Oh air temperature. That is the air temperature so we can put that on there. And do we have another one?

G: Wind speed

T: Wind speed. Let’s see. Oh, so on this day, there was no wind. What does that mean?

24:24

T: There’s no wind. What does that mean for our oxygen levels? Yes, A.

G: [inaudible too quiet]

T: The oxygen can not get into the water, so not only is there increased water temperature, but there’s increased air temperature [pause] and there is no wind on that day. [pause]

25:20

T: Also caused less dissolved oxygen. Oh man these fish were in for it, huh? [pause] Oh no. Were there any other factors? What do you think, J?

G: Why did the minnows survive?

T: Oh, that is an issue. Let's look at it.

B: The minnows could fly.

T: [laughs] yeah that is funny. Alrighty, so we've got the bass, we've got the minnows, and we've got blue gills. Huh. So at this point the minnows did not die. J brought that point up. Why do you think that is? What are some hypothesis for why that might be? What do you think, M?

G: Maybe the large mouth bass and the blue gills were predators to them so they weren't eating them anymore.

26:24

T: Oh, so after July 28th, when there were no more predators what happened to the minnows?

G: It increased.

T: That increased. That sounds like evidence that might support that. Ok. So when we're talking about fish, we're talking about its effects on different kinds of fish. So the larger fish were more affected. That might be because they need more oxygen. So the larger died because they needed more oxygen, which caused an increase in the minnow population. Yeah. Because they were predator/prey.

27:30

T: Huh. Any other factors we need to look at ? We've got turbidity, chlorophyll, cloud cover. What about the herons? Did they cause the fish to die? What did the herons do? What's the story with the herons? Let's put that on there. What happened with the herons? What's the relationship? K.

G: The population went up, but they didn't kill them, the fishes, because they just ate them when they were dead, like they started eating them when they were dead.

T: Oh what's that word called when they eat them when they are dead?

28:26

T: Oh, it starts with an S. I like that.

G: Scavenger.

T: Scavenger! There we go. Alright. So that caused, the larger fished died, and the herons because they were scavengers eat them. So my arrow should go the other way. [pause]

29:15

T: Alright. Wow.

TA: Ms. R. I wonder if anybody could start at the beginning and walk us through the whole thing so far.

T: That would be really good for your summaries. Definitely.

TA: All the stuff that we've written. Does anyone think they could start at the top and walk us through it orally? J, can you do it? Oh go for it!

29:39

G: The fertilizer had nitrates and phosphates to get the grass to grow, but when the guy put down the fertilizer it rained and that made the fertilizer go into the pond, which made the algae population increase and then that made the chlorophyll increase. And because of the algae population increase the turbidity increased because more algae organisms. And then that produced less sunlight, which made less photosynthesis, which made less dissolved oxygen, that was also caused by no wind, increased air temperature and increased water temperature. And less dissolved oxygen made the larger the fish die because of respiration, and the herons ate the larger fish because they were scavengers and the larger, um, the larger fish's death increased the minnow population because there was a predator/ prey adaptation.

30:45

T: Whoa that was fantastic! Quite a mouthful.

TA: I just had one question. This right here. The larger fish died because? (inaudible]

TA: Why did the larger fish die? Because of the herons?

B: No.

TA: Why did the larger fish die, A?

B: There was less dissolved oxygen and larger fish use it during respiration.. [inaudible]

TA: Excellent. Thank you for clarifying that for us.

[pause]

31:47

T: Ok. There may be more things that you and your group put together, um that you would like to include in your summary. This is one story that has most of the variables, but there might be even more. Um, what I'd like you to do right now is produce, which is a summary of what happened in the pond.

G: [inaudible question]

T: I want you to use whatever story makes sense to you.

G: If that story makes sense can we just copy that down?

T: No because we're writing it as prose as paragraphs. We're not writing it as a map. Ok, so take a look here. Here are the directions. I'd like you to write a summary to describe the story behind why the fish died in the pond. I'd like for you to start, this is a little bit different from this map.

33:00

T: I want you to start with your initial hypothesis. What did you think it was before we started. And then show how you proved if your hypothesis was true or not. How many people started with a hypothesis that they found to be false? Yeah, what kinds of hypotheses did you start with. The fertilizer killed the fish. What was your hypothesis?

B: I thought that it was either the fertilizer or the herons that ate them.

T: The herons, right. A lot of people investigated to see. There was another one that some people thought. If you were the private investigator you might have seen this one. What do you think, J?

G: Uh, I thought that it was fertilizer on the gound, around the pond and that the herons stepped on it and carried it to the water…[paraphrased, difficult to hear- lots of background noise]

T: Oh like you're not supposed to walk your dog on fertilizer grass. Yeah. Some people might have thought the virus at one point, that the fish may have gotten sick and died, but we know that isn't true either.

34:15

T: I want you to start with your initial hypothesis. Like first I thought, and then continue. My hypothesis was. Make sure your claims, so a claim is statement of what you think happened. Make sure what you say is supported by some sort of evidence. Like a graph you were looking at before or some sort of explanation about why you know it's true. Use your evidence from your ecomuve papers to help you. And you can use this word bank, and some sentence starters in your summary. Take a look back at the summary rubric that makes it look like its from MCAST, but we're going to be using it too. What I am going to be grading you on is that you have all the main ideas in your own words. That the second bullet is vocabulary. It says that the author's words, in this case the story is accurately paraphrased and technical vocabulary is used when appropriate. So I'm looking for vocabulary use.

35:26

T: The next bullet is about organization. That you show that there is order and not just oh this thing happened and this thing happened and not an order, and I'll talk about order in a second. And finally that you are showing evidence . And if you flip back to the front again I have in the word bank, lots of words. And the secret words, I have lots of different words you can say to help you order your ideas. Ok, first, second, third, next, later, soon, meanwhile, that might be useful, eventually, the next day., before, after, finally, during, then, after that, last, lastly. These are all great words that you can use as transition words between sentences. M?

36:28

G: Are we allowed to use the computer to look something up [

T: Um you should be able to, I'll pass some of the papers around if you want to see the graphs. Um, words showing relationships. So this is important. You can say things like, this caused, therefor, as a result, the evidence shows that, I observed that, it was interesting that, my hypothesis was that. These are starters to help you out. Alright. What I'd like you to do, is in your notebook I'd like you to, in your notebook I'd like you to write a rough, not a rough draft, but planning ideas of what you are going to say. First, second and third. Ok?

37:25

TA: Yeah guys and Ms. S. and Ms. R, and I were wondering does this look familiar to you from last year? Did any of your 6th grade teachers use this rubric? Two hands. Do you remember which teacher used this rubric, A?

B: Ms. C

TA: Ms. C so you wrote a summary in her class and she used this rubric? T, which class do you remember this rubric from?

G: Ms. B.

TA: Ms. B in language arts. Cause guys writing summaries, do you guys remember we talked about the district goal of literacy? And summarizing was a 6^{th} grade target skill from last year. Compare and contrast is 7^{th} grade. So summarizing was supposed to be a strong focus of your school last year, but we didn't much summarizing last year. Some of us haven't seen this rubric before. Well that's good information to bring back to our leadership. Ok?

38:43

T: So I'm handing out a piece of lined paper, that's what I'd like your final to be written on. This is going to be an EcoMUVE grade. Instead of, some of you have noticed, if you have missing EcoMUVE grades, it has affected your grade. Notice, we didn't have any projects or labs this trimester, so this is our Ecomove grade. Anything from EcoMUVE goes in this green quarter. So this is part of your Ecomuve grade along with your presentations, all of your homework from EcoMUVE goes in there. Did anyone not get a piece of paper? So,

G: Ms. R are we getting our [inaudible]

39:40

T: Tomorrow. So I would like you to tonight, for homework, write yourself, write a rough copy on this paper actually, and we'll take them, and we'll edit them and we'll make them amazing. But I'd like you to write as much of the story as you can on this paper, trying to use those transition words, trying to use those causing words, this caused, and I want to see what you can do writing your rough draft on this paper. We'll take a look at them tomorrow too, but that means we're taking a look at them tomorrow so everybody needs to make sure that they spend time on this tonight. Your math homework is going to be very short so you should be spending time on this tonight. B?

40:38

B: [inaudible]

T: I'd like them on a separate sheet so that I can look at them. I'd like it on a separate sheet.

G: [inaudible]

TA: Well usually when we do a first draft we do double space it so that there's space for revisions and editing.

T: Ok. Sure, double space. You just skip a line every other line. Yep. Alright, you may go to your next period class for the day

41:21