**Instructor Story:** Using Systems Thinking in Introductory Biology Courses

Jessica Martin, Instructor of Biology, University of Providence

General Biology II Lab (BIO 152L) and The Living Environment (BIO 110ASY)

**Course Information:** BIO 152Lmet once a week, 2-hour lab session. Bio110ASY is 4 credit online/asynchronous course.

**Course Description** (From course catalog): [Bio 152] A continuation of BIO 151, this course completes the discussion of fundamental cellular processes with DNA replication, translation, cell division, and chromosomal inheritance. Other topic emphasis includes the study of populations, ecosystems, plant as well as animal form and function. Accompanying laboratory experience utilizes research processes and their subsequent application to real world problems.

 [Bio110ASY] All living things share certain characteristics and requirements. Though nonliving things may exhibit one or more of these characteristics, living things exhibit them all. This course will give students deeper insight and appreciation of how fundamental science concepts are used in emerging research and discoveries in the life sciences. Science is a clearly defined process. Both laboratory and science process skills are developed through hands-on activities and discussion contributions. Students will gain an understanding of science as a way to serve human needs and solve human problems.

**Course Context**: [BIO 152] A required foundational course for predominantly biology majors, but also forensic science and exercise science majors.

[Bio 110ASY] An option for fulfillment of the Experimental Science core curriculum requirement.

**Course Goals and Topics:**

***Topics:*** Ecology, ecosystems, natural systems

***Goals:*** Demonstrate how a natural system works.

Demonstrate knowledge of systems in building an aquaponics system [BIO 152L]

Summarize how aquaponics/hydroponics are modeling earth processes [BIO 152L]

Investigate the concept of sustainability within biology and relate these concepts to society and other disciplines [BIO 110ASY]

**Materials Used**

Systems Thinking Module; specifically Units 1-3

<https://serc.carleton.edu/integrate/teaching_materials/syst_thinking/index.html>

**Introductory Summary**

The Systems Thinking module was used during a 2-week span of time in a General Biology II Lab, in conjunction with learning about ecological principles and ecosystems. Unit 1 was a stand-alone activity for one week and the second week the students were asked to apply their knowledge and build a functional aquaponics systems utilizing a ten-gallon fish tank. It was also used for a weekly unit applying the same ecological principles to a Human influenced effect on the natural world, such as acid rain or the greenhouse effect in a non-major’ biology course.

The module was great for the lab setting, especially in modifying/combining Units 2 and 3 to allow the material to work with the already existing aquaponics activity. Unit 1 was more of a lecture type of unit which I typically shy away from in lab, but it was exactly the brainstorming activity I had noted was missing from the aquaponics activity previously. This was perfect for what I was looking for to bring the aquaponics activity to more of a solid thinking and understanding of functional natural systems in my students. It helped that our labs are small (4-16 students) and that we had enough space and supplies in our greenhouse to do this activity. The online/modeling tools in Units 2-3 would have been utilized if we did not have the ability to build our own.

For the online course, it was tougher to really connect with the students. In the future, I would find a better way to get the students to really work together on their ideas and interact in brainstorming, which is crucial for the functionality of this unit. I wasn’t satisfied on that in my course, which was more a reflection of my online teaching more than the module.

**Inspirational Quote**

Using the Systems Thinking module enabled my students to really connect to biological and natural systems around them. I had one class apply these ideas to building an aquaponics system in lab, an activity that has been an overwhelming success. This module really made it click in my students how the pieces of a system work in conjunction to the whole!

**Modified the Module?**

 I followed Unit 1 to the letter, where I just used the major ideas behind Units 2-3 to have my students create a system based on a topic and label the basic terminology, such as fluxes, reservoirs and feedback loops.

**Module in Course:** This material was integrated into the latter section in both courses (Ecology and Ecosystems). Because both courses were introductory and overviews in nature, I could not dedicate the time required in all of the units of the module. However, in my lab course (Bio 152L), I could complete Unit 1 completely in a single lab and then integrated Units 2 and 3 together into the following lab period. The students were required to monitor their system until the end of the semester, which was a few weeks. In my online course (Bio 110ASY), I dedicated a whole weekly exercise to the 3 units (which would have taken roughly 3-4 hours of time, depending on the student).

**Week 1/Unit 1 Notes:**

*Unit 1: Introduction to Systems Thinking – What is a System?*

<https://serc.carleton.edu/integrate/teaching_materials/syst_thinking/unit1.html>

 This unit was useful and just what I was looking for the supplement my aquaponics activity. It was noted that this was a “dryer” kind of lab, more of a lecture style than students were used to. However, each group (4 lab sections) pointed out different examples of natural systems and quickly connected feedbacks to concepts previously in their biology courses.

 My own thoughts on the module were that the style exposed a flaw of mine, jumping in too fast in quiet moments. There were a few times where my students weren’t overly enthusiastic and I jumped in a little fast to keep the conversation going. I did get some great feedback on this Unit though, I had multiple students say it was boring until the next week, where everything clicked together while they were building their systems!

 This was a more difficult unit to do online. I had a hard time facilitating discussion among peers in the group, though their responses showed a great understanding of the concept, especially after completing the exercise fully. I actually also used this unit in discussing greenhouse gases in an earth and space course this semester too. Overall, I really like how it connects things together.

*Unit 2: Picturing Complexity and Unit 3: Modeling a System*

<https://serc.carleton.edu/integrate/teaching_materials/syst_thinking/unit2.html>

 I greatly altered and combined these two units to fit a previously existing aquaponics activity in my BIO 152Lab. Before building their systems, I had students sketch out their model and draw and label feedback loops, fluxes and reservoirs. I had the students in each section tape their drawing to the board in the classroom before heading out to build their aquaponics system. I wanted/encouraged the students to use the board as a “gallery-walk” before heading out. This didn’t work overly well, as the excitement of actually constructing their plan was too enticing. However, many did look at others designs after they built their system or used the diagrams to help work out kinks in their plan. The aquaponics systems were largely successful and began to sprout various vegetables and greens before the semester ended.

 For my online class (BIO 110ASY), I prompted the students to identify a human related issue (in conjunction with the chapter “Human Influences on the Natural World” in their textbook) and had them sketch out/model their system. They were required to label terms on this as well. This went surprisingly well and it was noted by many students that doing this second part was what made the whole week click for them, applying that knowledge to a real system.

**Assessments**

I used the provided Systems Thinking assessment in Unit 1 for both classes. I had both take survey before and after the lesson, while writing any notes they had (questions, etc.) on those surveys as well. The students received them well and were apparently honest in their assessments of themselves.

For Units 2 and 3, I assessed the students’ understanding through their drawing and labeling of their diagrams. There were a few students who misunderstood some feedback concepts through these diagrams. I did not use the provided assessments for these units as I altered teaching the concepts.

The final assessments were on final exams in both courses. For both, I asked a fill in response question to distinguish between positive and negative feedback loops. I asked the BIO 152L course if an aquaponics systems was positive or negative, a majority of the students got it, though some showed confusion of the terms. I had the online group (BIO 110ASY) answer similar prompts and they did well at labeling feedbacks and other pieces of a system.

**Outcomes**

The Systems Thinking module was used within two introductory biology courses after our department noticed a great need of understanding of how natural/biological systems worked. While we taught about systems, our students seemed to struggle how it all worked on a whole. As we looked to improve and integrate sustainability in our classrooms, this module seemed to be a great fit for that lack in my specific courses.

 I am very happy with how the utilization of Units 1-3 went in my courses. I so was enthused about how thinking of systems can be applied across courses that I also added these units to an Earth and Space course I was teaching this semester. It was a great tool to apply to all sorts of natural systems thinking, so I was able to relatively easily adapt it to different topics we were discussing. The whole module seemed a bit long to do all of for my specific courses, but the material helped fill a whole I saw in some of our students. They were able to see a system as a whole AND by its parts, and showed better understanding of how natural systems rely on the parts and whole. This helped connect some of the human influences we discuss in the world and its effects on natural systems, which was a good eye opener for some of these students. All groups could successfully demonstrate how a natural system works and apply this idea either to aquaponics and/or to a human influenced process in nature.