A visual representation of three-dimensional learning: A tool for evaluating curriculum

by Ana Houseal

This is a transitional time, between the launch of the *Next Generation Science Standards* (*NGSS*) in 2013, its adoption in 14 states and the District of Columbia, and ongoing discussions regarding adoption in many others. Teachers in states that have adopted the *NGSS* and states considering the *NGSS* or similar standards will need tools to assist in curriculum development. One such tool, a model called *A Visual Representation of Three-Dimensional Learning*, based on *A Framework for K–12 Science Education* (NRC 2012), is valuable not only as an explanatory model, but also as a straightforward evaluation tool for assessing alignment of current curricula with the *NGSS* (see Figure 1). This model complements the EQuIP rubric (Step 2: Apply Criteria in Category 1: Alignment to the *NGSS*) as it helps individual teachers quickly identify initial alignment of curricular materials to the *NGSS* (see Resources).

This article focuses on demonstrating the power of visually representing the *NGSS*'s three-dimensional learning model using a middle school lesson acquired from the internet. This article will work through the lesson much like teachers would do when evaluating their own lessons.

Bybee (2013) proposed in his book, *Translating the* NGSS *for Classroom Instruction*, that while we are waiting for published curricula to catch up with the changes in the standards, we will need to look at current instructional pieces and modify them. He also noted that, "When beginning with materials that were developed for a different set of standards, there is a limit to how completely they can be adapted to the *NGSS*" (p. 139). An important place to begin is by mapping lesson alignment to the three dimensions of the *Framework*.

What is a lesson?

For the purposes of this article, a *science lesson* is defined as an activity or set of activities that teaches a complete concept. A lesson can include activities that teach skills, such as microscope use or titration, but the lesson objectives primarily are about the knowledge, understanding, and possible application of one or more scientific concepts. In addition, a lesson might extend over several days and contain multiple activities. The lesson in this paper has multiple activities.

Many lessons will be required for students to develop skills to reach proficiency for a particular *NGSS* performance expectation (PE). In this article, the selected lesson focuses on parts of the identified Standards; however, they cannot address them completely, thus demonstrating the need to closely attend to the curriculum as a whole when working to meet Standards.

The model

This model (Figure 1) shows the dimensions of the *Framework* encased in a triple Venn diagram and describes what each of the dimensions might look like in a classroom setting. The colors of the circles were purposefully chosen to match the colors used by Achieve in the *NGSS*, making them easily identifiable. It assumes that the best way to think about teaching and learning science must include all three dimensions.

Each dimension is defined outside of the Venn diagram. Then, within each of the circles, examples of the dimensions are presented alone, without any connections to the other two. Where the circles overlap, examples highlighting the intersection of two dimensions, without the third, are presented. Finally, in the center, where all three dimensions meet, the *NGSS* PEs provide examples of what science should look like. The middle school life science PEs in the box on the bottom right are directly related to the lesson evaluated in this article.

Lesson selection

The lesson selected is not an exemplar developed using the *Framework* or the *NGSS*. This was purposeful.

While many lessons will be created using that lens, many others will continue to be available to teachers that are not aligned to the *NGSS*. The purpose of this article is to provide a tool for teachers to use to identify the alignment and make changes to existing lessons, thus moving more curricula toward the center of the model.

Reviewing a popular science lesson

The lesson plan of a popular activity taught in many middle school classrooms was discovered using a Google search and selected from one of the top five Owl Pellet Lesson Plan hits to review and evaluate. The technique can also be used with any previously designed and taught lesson plans. The lesson to be examined, "Barn Owl Pellet Lab," was developed in 2012 for the seventh grade by Debbie Payne, Ruth Liddell, and Shirley Scarbrough at Alabama State University through a math–science partnership (see References).

This 5E lesson plan (Engage, Explore, Explain, Elaborate, and Evaluate) consists of seven different activities. The 5E learning cycle was developed by Trowbridge and Bybee (1990), building on Karplus and Their's work (1967). This plan follows a linear sequence, beginning and ending with an identical pre- and postassessment. The assessment consists of 10 recall questions—five of which can only be answered by reading the provided text, and another five that could demonstrate learning from the other activities,

FIGURE 1 A model of the three dimensions of science learning

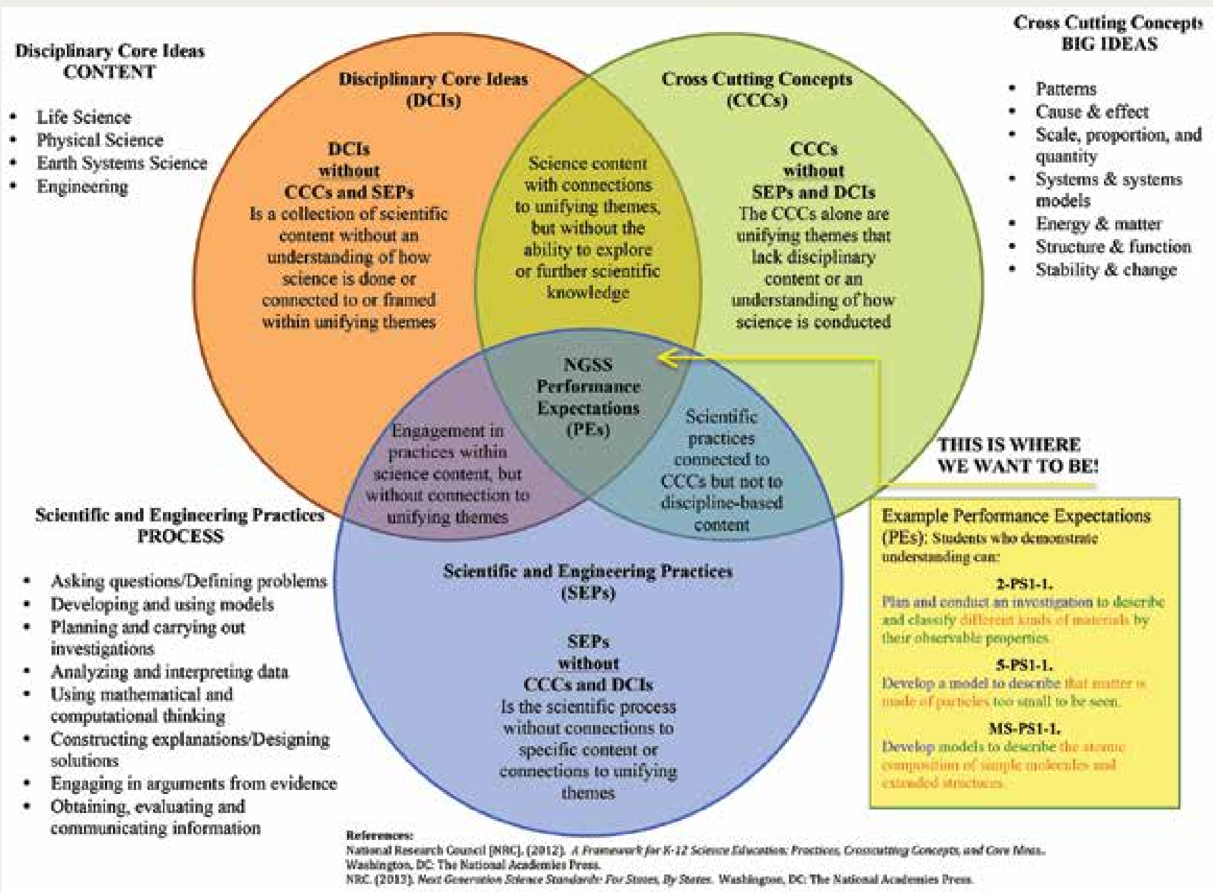
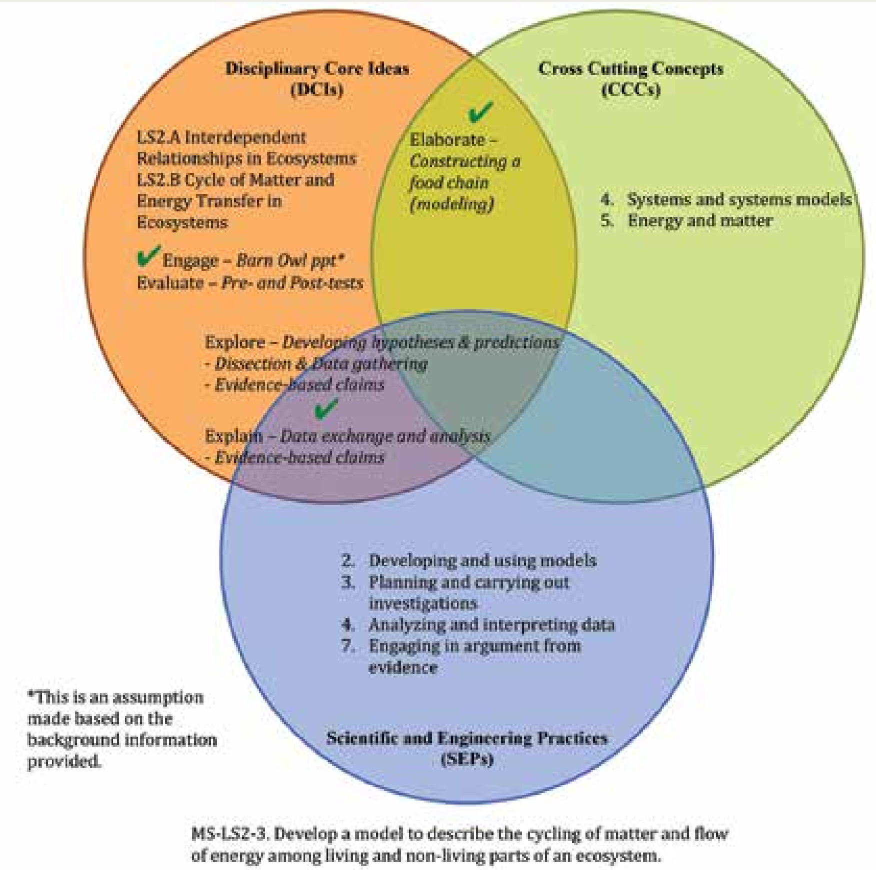


FIGURE 2 Mapping the owl pellet lesson



but could also be answered simply by doing the reading and not engaging in any of the activities, including the dissection, data collection, sharing, and analysis.

The Engagement part of the lesson includes the pretest described above and a presentation about barn owls. The presentation was not included in the lesson plan.

For the Exploration, students develop a hypothesis and predictions based on the following predetermined question: What does a common barn owl eat and how much? (Owl Pellet Handout #1, p. 31). To answer the question, students dissect a barn owl pellet and gather data on the number of skulls, bones, and other materials found within it. Finally, using a provided Owl Pellet Handout (#3), students determine the pH of their pellets and make an evidence-based claim to explain what their results might mean.

During the Explanation portion, student groups exchange data, compile a whole-class data set, and develop frequency tables and a frequency distribution graph. One of the worksheets asks students to make statements (a) about the correlation between weight of pellets and number of skulls, (b) accounting for differences in content among pellets, and (c) explaining the absence of skulls in some pellets.

Elaboration consists of three activities. The first is a teacher-presented PowerPoint with a discussion. The PowerPoint is not provided. In the second activity, students arrange and affix the bones from the pellets to "bone cards." Finally, students are asked to construct a food chain based on the owl pellet dissection that consists of at least one producer and three consumers. It is possible that information for this activity is included in the PowerPoint and discussion mentioned above, but there were no instructions in the 36-page online document.

Finally, the Evaluate portion of this lesson consisted of the posttest, which was identical to the pretest.

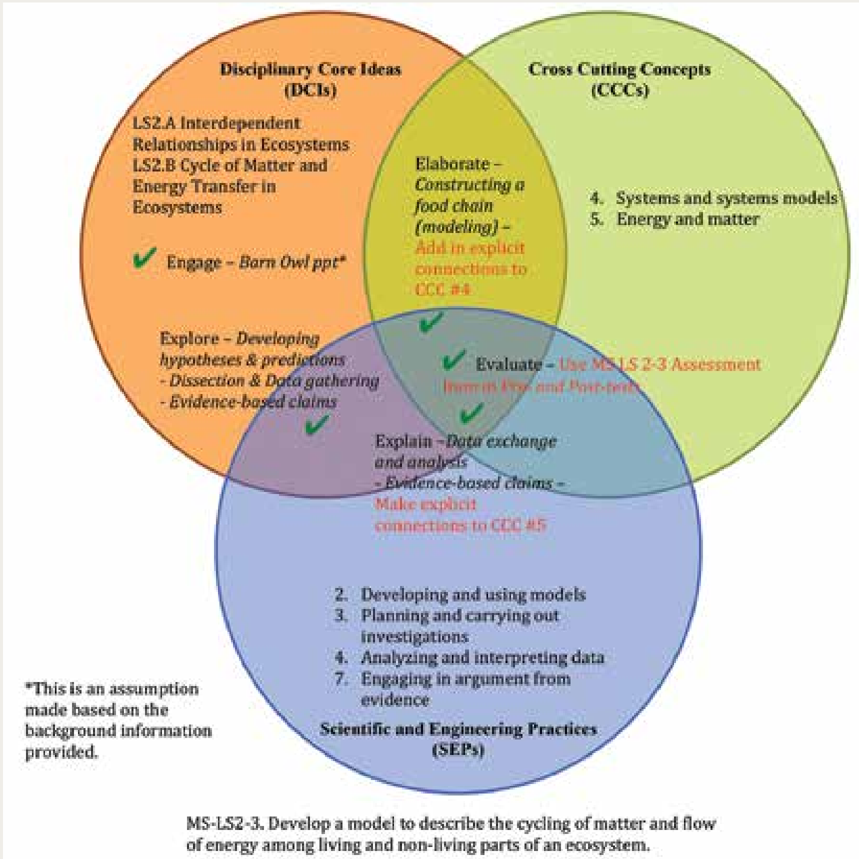
Mapping the lesson

In Figure 2, the disciplinary core ideas (DCIs), crosscutting concepts (CCCs), and science and engineering practices (SEPs) are printed in plain text, as are the 5E lesson labels. The activities are written in italics, and the green checks indicate how well this lesson maps to the *NGSS*.

While I could only map what was provided, I made an assumption that the PowerPoint included information similar to the background information presented in the packet. The pre- and posttests made no explicit connections to any SEPs or CCCs. This is why one green check is placed in the orange circle.

The second check, located in the intersection between the DCIs and SEPs, indicates the merging of content and practices in the Explore and Explain portions of the lesson. The SEPs listed in the blue circle show that this lesson, as a whole, addressed parts of four practices.

FIGURE 3 Remapping the owl pellet lesson with recommendations



The Elaborate activity, constructing the food chain, was the most difficult to map. Arguably, it could have been placed between the DCIs and SEPs instead of within the intersection of the DCIs and CCCs, where the third green check is located. Upon review, it seemed that the intent of this activity was to demonstrate the flow of energy in ecosystems by developing a simple food chain. This brings up another question: Why, since it could have been mapped in either location, would it not be placed in the center? While the content could be connected to the system (via this simple model), there was no indication in the lesson that students would be made aware that they were developing and using models.

The ultimate goal is three-dimensional learning. If the lesson maps to each of the dimensions separately, in other words, if there are checks in each of the dimensions outside of the overlapping sections or the center, this goal is not met. Therefore, lessons that fall into the crossover sections already integrate two of the three dimensions, and should be considered better than those that stand alone. Ideally, at least one activity within an entire lesson or the summative assessment will map in the center. This matches with the *NGSS* PEs.

Recommendations

What would it take to make this particular lesson into a three-dimensional lesson and move it to the center of the model? While this lesson currently maps outside of the center, it could easily be moved to the middle with a few alterations:

*1. Make more explicit connections within the content to the CCCs***,** especially to Systems and System Models and Energy and Matter. Descriptions of these two CCCs follow, indicating how they correspond with this lesson. For CCC #4, Systems and System Models, this might include the addition of explicit instructions to the Elaboration portion of the lesson regarding ways in which developing models of the ecosystem in the food chain activity helps both students and scientists better understand ecosystem relationships. For CCC #5, Energy and Matter: Flows, Cycles, and Conservation, when students are developing frequency tables and a frequency-distribution graph during the Explain portion of the lesson, this might include additional instructions regarding the connections of these data to the fluxes of energy and matter within the system to help students understand the limitations of the ecosystem.

CCC #4—*Systems and System Models.* Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

CCC #5—*Energy and Matter: Flows, cycles, and conservation.* Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations (NGSS Lead States 2013, Appendix G, p. 1, emphasis added).

2. Frame the structure of the lesson using these two CCCs. In other words, use *Systems and System Models, and Energy and Matter* as the main ideas around which all of the activities are based, and all activities are tied. This would strengthen the content, data gathering, exchange, and analysis.

3. Develop new assessment items that require students to demonstrate understanding of three-dimensional learning in the pre- and posttests. For example, using the PE for *NGSS* MS-LS 2-3, a revised assessment item for this unit could ask students to: Develop a model (in this case it would be a pictorial representation) of the flow of energy (as represented in a food chain or web), within an ecosystem that represents the barn owl's habitat. As an item in a pretest, it would give the teacher an idea of current understanding, and at the posttest, both teacher and students could easily identify and reflect on student growth.

While this assessment prompt does not match the first two objectives stated in this lesson (a) "The student will be able to dissect an owl pellet" and (b) "The student will be able to identify the animal skulls and other bones found in the pellet," it goes beyond what is proposed in the third (c) "The student will view a PowerPoint presentation and participate in an interactive class discussion to learn basic facts about the barn owl, food chains and food webs" (Payne, Liddell, and Scarbrough 2012, p. 1). Beyond the clear connection to the *NGSS*, the proposed assessment also is an excellent match to the original Standards listed in the lesson, which talk about (a) ecosystems having complex interactions between organisms and the physical environment, (b) what animals in an ecosystem might consume and use, and (c) the energy needed for all organisms to stay alive and grow.

Figure 3 demonstrates the remapping of this lesson with the proposed recommendations.

Conclusion

Because individual teachers are responsible for implementing lesson plans of their own, sometimes incorporating activities found on the internet, various manifestations of the lesson can occur. Consequently, the *NGSS*-mapping tool described in this article is a strict interpretation of the intended curriculum by the author—what is written in the lesson plans, not necessarily the enacted curriculum—which is how the lesson is executed in any given classroom.

The lesson to be learned in this exercise is that there are myriad activities on the internet and in textbooks that could meet all three areas of the *Framework's* dimensions if examined thoroughly and altered as necessary. While this can be a new process for teachers, this model is useful in identifying and providing guidance to help fulfill evaluating alignment and revising current lessons and activities. ■

References

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Resources

EQuIP rubric—*http://ngss.nsta.org/Documents/BasicEQuIP.pdf*

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