The Faults in Frontloading Science Content

by Rebecca Grainger

Over the last year we’ve been collaborating with teachers in several districts around novel studies and incorporating young adult literature into their curriculum. We’ve been helping to identify readings for students that provide a steady diet of both windows—texts that allow students to see into events and lives different from theirs—and mirrors—texts that reflect students’ cultures and personal experiences.

In secondary science education, a common practice involves the use of large amounts of time to introduce and teach foundational ideas. We frontload in the hopes that the foundational information will lead students to deeper understandings of more complex ideas. Take for example the teaching of inheritance. Prior to attempting to understand the complexity of inheritance, we often ask students to first mentally tackle the structure, function, and replication of DNA and the process of forming gametes (sperm and eggs) through meiosis. While these are vital to the process of inheritance, is this background knowledge vital to learning about inheritance?

Students are interested in inheritance because they are given the opportunity to think about the process that makes them unique. In the absence of extensive foundational information, inheritance naturally gives rise to questions about DNA and sex cell formation. Once students have begun inheritance studies, these foundational concepts can then be taught within that context and with increased interest. Additionally, within the context of inheritance, a greater focus on relationship between the core ideas can occur. A focus on relationship can take the place of the memorization of isolated facts, such as the structure of DNA or the steps in meiosis. This focus on relationship can serve to support and strengthen a deeper understanding of inheritance and the contributing factors, such as the role of DNA. We can save time by not emphasizing fact memorization and replace the memorization with students’ questioning and seeking additional information to deepen their understanding.
Teachers are so consumed with the large amount of content to cover in science and the limited time to do so that they turn to asking students to memorize foundational information. So often, under the pressure of time, students never have the opportunity to tackle the complex ideas for themselves and, for example, develop a deeper understanding of inheritance. When this happens, students and teachers become frustrated with the results. Students are left confused and unable to connect all the foundational ideas, let alone to make a connection to the more complex idea of inheritance.

This struggle leads me to ask if we are spending too much time and effort providing foundational content rather than utilizing limited time asking students to monitor and question their understandings and grapple with complex ideas. And is the end product worthy of our effort? Are we achieving what we want to achieve in terms of student understandings and skills?

**Questioning the Purpose of the Science Classroom**

The practice of science is much more than learning and memorizing content knowledge. The notion that the science teachers’ singular role is to present science content is a narrow view of what it means to learn and do science.

Frontloading material, trying to give students all the content they might need upfront, prevents them from engaging in important skills. Students, for example, benefit enormously from figuring out what they don’t know, seeing where they have questions, and identifying the additional information they need. Likewise, students benefit from developing the ability to self-advocate for additional information or seek help in exploring a new way to solve a problem. Students must develop the confidence and wherewithal to recognize that lack of information or confusion is not a reflection on their ability or IQ. We short-circuit the development of these important skills when we try to give students all the information we think they need to understand concepts or solve problems. By giving them all the knowledge upfront, we also undermine their understanding of how scientists work when they have to spend considerable time digging into research to answer their own questions. While all of these self-advocacy strategies are examples of skills students of science need to learn, they are also skills vital to students outside of science.

It is not realistic to expect students to develop information-seeking and problem-solving skills if we don’t engage them in these practices. Rarely are we given everything we need to solve a problem outside of the K-12 classroom. Living in the digital age, students have fast access to sources of content. If we use all of our time frontloading content in our teaching, we won’t have time to allow students to struggle with figuring out what they need to know and learning how to get it.
Does It Even Stick?

The human brain doesn’t absorb large amounts of new information all at once, especially when the information appears obscure and isn’t contextualized. The frontloaded material that we give to students within a sequence of learning based on the lens of our own understandings is not the same view that a developing learner holds in the face of these onslaughts of information. We can see the road map and context because we create the map and have previous exposure to the content. The sequences and connections of information that we see and automatically turn to are not so illuminated for students.

Studies show that less than 30% of what students hear through lecture, the typical way we frontload information in science classes, is retained¹. If students are not retaining the frontloaded material for later application to the complex ideas, why do we do this? Instead, we should present students with content as it is relevant to the inquiry at hand. Further, we should guide students in questioning their own understanding and seeking out the information to help them to confront their struggles and quench their curiosity. In large part we can accomplish this by teaching them how to identify the questions that they need to answer and then showing them how they can work together to answer those questions.

Students benefit from developing the ability to self-advocate, knowing when and how to seek help, and realizing that struggling, being frustrated and experiencing confusion are a natural and necessary part of the learning process—for everyone. Students should have the ability to realize that they needn’t know everything right now and that developing deep understandings is hard work. They must come to this realization before they leave high school to help them succeed in the future.

Moving Forward

So how might we foster productive struggle and problem solving in the science classroom? We can start by providing time for students to struggle with complex concepts. We can ask students to take the time to reflect on new ideas and understandings. We can apprentice students in making connections to previous learnings and experiences and then allowing them the time to do so. We can provide students five minutes to gather and record their thoughts before beginning a discussion. We can present lessons through the lens of exploring ideas rather than presenting truth. We can ask students to question what they are learning and to seek out clarification when confusion arises. We can ask students to be active in their education rather than asking them to regurgitate given information. We can do all of

¹ http://net.educause.edu/ir/library/pdf/ff0814s.pdf
this in lieu of providing frontloaded content through lectures and textbooks. Students cannot improve their process of thinking without first being provided the time to think.