

Taking Our Own Medicine: Revising a Graduate Level Methods Course on Curriculum Change

by Rudolf V. Kraus, Rhode Island College; & Lesley J. Shapiro, Keene State College

Abstract

Implementing the Next Generation Science Standards presents challenges for practicing teachers. This article presents our reflection on creating and revising a class designed to teach inservice teachers about curriculum change and the Next Generation Science Standards. In its initial iteration, the course was designed to address the intellectual and practical aspects of this change in standards. Interaction with teachers, as well as gathered course reflections, indicated that addressing the process of curriculum change is both a practical task and an emotional one.

Introduction

The Next Generation Science Standards (NGSS, 2013), are the most significant change to American science education since the publication of the National Science Education Standards (NSES) in 1996 (Yager, 2015). They represent a radical departure in both content and pedagogy from the previous standards and models of science education (Bybee, 2014; Pruitt, 2015).

As a faculty member at the largest teacher-education institution in Rhode Island, the lead author felt that helping in-service teachers make the transition to the NGSS was a priority. To target in-service middle and secondary science teacher, he wrote new curriculum for a three credit graduate-level class which could be taken as a stand-alone or as part of a M. Ed. degree because there are currently no state-mandated professional development requirements for teachers in Rhode Island. This class focused on curriculum change, specifically the upcoming shift from the previous state standards, the Rhode Island Grade Span Expectations (RI GSEs), to the NGSS. This article will discuss the course design and revisions, the impetus for those changes, and the lessons learned. In its first iteration, this class was taken by the second author and both authors have since revised and taught it together.

All three times that this class has been offered, participating teachers were looking ahead to the NGSS and the state testing aligned to it, beginning in the spring of 2018. The disconnect between adoption and implementation created a multi-year period during which the NGSS were the official standards but schools and students were evaluated with an older test aligned to the previous standards (RI GSEs). In order to support improved student performance on high-stakes tests, many teachers continued to use their old curriculum that

was aligned to the RI GSEs. Additionally, in our high-stakes teacher evaluation system, failure to meet growth expectations in student learning results in a lower rating; innovation is discouraged (Mangin, 2016).

Version 1.0

Version 1.0 of this course was conducted in the fall of 2013, less than six months after our state had adopted the NGSS. The required textbooks for this course were the Framework for K-12 Science Education, the standards document, and the appendix volume which includes All Standards, All Students, and many other resources for changing the paradigm of science education. As we explored the NGSS, the first author reminded the teachers that this was new to everyone else and that there were no teachers in our state, or any other state, with even a year of experience under this new paradigm, which emphasizes sensemaking versus rote memorization. As one teacher described it:

[The] NGSS sets guidelines on promoting and encouraging students to solve problems, work collaboratively, and apply concepts in a real life situation. Rather than being content heavy, the standards stress how to get to answer rather than memorizing the answers. Facilitation by the teacher requires that students come up with the “answer,” rather than the teacher giving the answer or handing out a cookbook lab for students to repeat.

While the college had an existing graduate science methods class, the first author felt that the move to an entirely new set of science education standards warranted a new curriculum. Rhode Island had pre-existing science standards (the RI GSEs) and a state test to assess them. Teachers were familiar with this structure and had aligned lessons and units to it. These teachers were being asked to replace a known structure into which they had invested a great deal of time and effort with an unknown structure. In order to successfully teach the NGSS, the first author felt that we needed to address the underlying question of “Why are we doing this?”

Course Design and Theoretical Framework

The initial framework was a historical survey of curriculum change in science education. The first author’s original approach was to move from a broad timeline and scale to one that was more local as the semester progressed. While small and moderate scale curriculum changes, such as modifying a lesson or adopting a new textbook, are common enough, changes in the purpose of a curriculum, such as those that occur with a change of standards, have a wide-ranging impact and happen rarely (Fraser & Bosanquet, 2006).

During phase one of the class, the teachers examined changes to science education curricula from other times and places. Phase two of the class looked at the transition to the NGSS in great detail, including the motivations revealed by the Framework for K-12 Science

Education (National Research Council [NRC], 2012). The final project was to create a scope and sequence for one of their classes aligned to the NGSS.

Rather than dive into the NGSS from the outset, we looked at a variety of other changes to science education in order to situate this change in a historical context. After addressing broad historical change, we then focused on the classroom level. At each point, discussion centered on the following questions: What were the benefits of change? What were the drawbacks of change? Who suffers? Who benefits?

After concluding phase one, the course content shifted to focus on the NGSS and what this transition entailed. The first author modeled several three-dimensional science lessons that teachers were able to experience. One example was the fruit lab, a density lab that calls for students to generate their own question about the sinking and floating of different types of fruit, design a procedure, and evaluate their results. This lab allowed for the introduction of the Herron Scale (1971), which is used to classify the level of inquiry in laboratory work, and allowed teachers to see how the level of inquiry in a lab could be dialed up or down through modification of the instructions. The class examined how a lesson could simultaneously have a content objective, include several practices of science and engineering, and connect to crosscutting concepts. This three-dimensional structure means that the NGSS are structured very differently from our previous content-based state standards.

The unique structure of the NGSS necessitated a detailed lesson in how to read a performance expectation. In many places, teachers asked “Why did they change it?” The Framework for K-12 Science Education, along with NGSS appendices F and G, were important in revealing the three-dimensional structure of the NGSS. They also helped teachers develop the knowledge and vocabulary to discuss the disciplinary core ideas (DCIs), practices of science and engineering (PSEs) and crosscutting concepts (CCCs).

Once teachers grasped how to read a three-dimensional performance expectation, the next order of business was to understand the organization scheme of the NGSS. The size of the document was initially daunting to the teachers but they learned that the standards are listed twice in the main book and represent 12 years of science education. Knowing they were responsible for teaching the standards contained within a few pages, rather than the entire document, came as a relief. Teachers also learned that the standards were part of larger K-12 learning progressions, which answered their questions about the starting and ending points for their own curricula.

A change in standards means that some topics are taught in different grades or not at all. Another question that teachers asked was: What will I be teaching? To answer this, teachers were asked to select the model from appendix K that best matched their school’s science program and explain its alignment to their existing program. The discussion that ensued

expanded to include other concerns such as deficits in teachers' content knowledge and problems related to resource acquisition within schools. Our state has been and remains one where resources are distributed inequitably.

Curricular change can force a teacher into different, less familiar content and therefore reduce their classroom effectiveness. Given the teacher evaluation system in our state, this was a fate that deeply concerned the teachers. The first author designed the four circles activity to help teachers bring a critical eye to their current curriculum and identify areas of stability as well as areas of change. They were asked to take a look at the units they were teaching now, and divide them into one of four categories: Aligned with the NGSS as is, Aligned to the NGSS with minimal revisions, Aligned to the NGSS with major rewriting, and Incompatible with the NGSS (Figure 2). Teachers self-reported how their curriculum aligned to the NGSS and initially focused largely on the DCIs. This focus on content was not unexpected and teachers need to be prompted to repeat this process twice more with the PSEs and CCCs. In designing their scope and sequence, some of the teachers reused this activity at the lesson level to select lessons for inclusion. Since the NGSS were released in the spring of 2013 and the first version of this course ran in fall of the same year, many of the structures that currently exist to verify alignment, such as the EQuIP Rubric, had not yet been created.

Figure 1 (Click image to enlarge). The four circles activity.



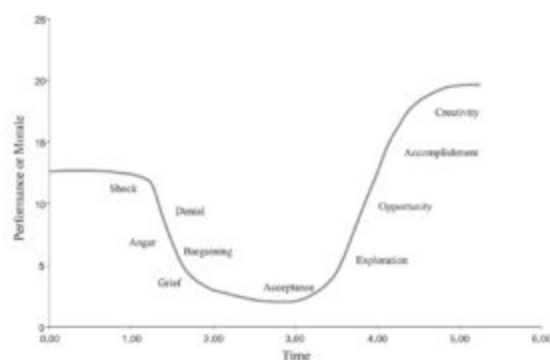
The culminating activity for the course was for the teachers to design a scope and sequence for a single full-year class. This required the teachers to develop a timeline for instruction that included one-third of the content standards for their grade band, all of the PSEs, all of the CCCs, defined units of study based on the three dimensions of the NGSS, a reasonable timeline of instruction, measurable and observable objectives, sample lessons for each unit and Common Core alignment.

Lessons Learned

The primary lesson learned is that this is an emotional process for teachers. The first author had designed the course around an intellectual justification for curriculum change and was less prepared to address teacher concerns about becoming less effective, the disorganization that comes initially with any change of this magnitude, and their professional opinions about what they thought should be in the curriculum. To address these needs, the first author consulted the literature on organizational change and centered the course on a new theoretical framework.

Several different models of change curves exist, though all share some common themes (Elrod & Tippet, 2002; Sotelo & Livingood, 2015). In general, the initial moment of the introduction of change is generally followed by a period where productivity, motivation, or views of self-efficacy decrease (Elrod & Tippet, 2002; Liu & Perrewe, 2005). A middle transitional period follows this wherein productivity, motivation, and self-efficacy reach their lowest point and begin to increase. The ending transitional period sees an increase in productivity, motivation, and self-efficacy as individuals become proficient in their new roles or with new skills. The Bupp change curve (1996) [figure 3] was selected so that the teachers would have a framework with which to understand both historical and present curriculum change.

Figure 2 (Click image to enlarge). Bupp's change curve.



Introducing the change curve had an additional effect on the class; emotions became one of the official topics. The change curve made it more acceptable to discuss the teachers' private feelings and lowered the usual barrier to talking about emotion in the workplace. Comments like "I'm feeling denial today" or "I'm definitely over here" [pointing to the change curve] were common.

The adoption of the NGSS occurred at the same time as the revision of our state's educator evaluation system. The new evaluation system created significant angst for teachers as it was linked to certification and employment. One of the proposed changes to evaluation, which has since been dropped, weighted half of a teacher's evaluation on student performance on the state's high-stakes tests. For teachers in the first version of the course, this factor was seen as professionally threatening.

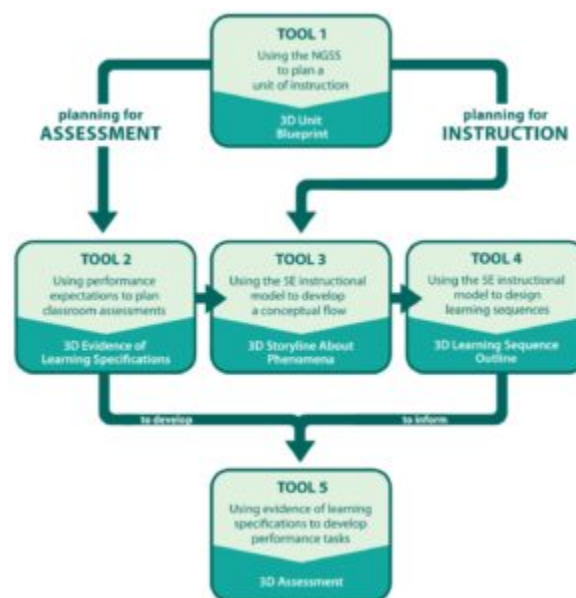
I anticipated a greater skill set from teachers in the area of curriculum development. Teachers wanted reassurance that they were "doing it right". Sadly, teachers were unaccustomed to having their professional voices taken seriously. Most of their previous experience involved implementing a curriculum picked out by others as prescriptive curricula have become more common in science education. Purveyors of these curricula focus their professional development on training teachers to use their materials as opposed to

developing the teachers' capacity to design their own. Due to time spent teaching basic curriculum writing skills, it became necessary to jettison the plan to align Common Core reading and mathematics standards to teachers' scope and sequence.

Version 2.0

The second version of this class ran in the spring of 2015. By that time there was a wider variety of resources available to help teachers learn about the NGSS. After attending a one week workshop at the American Museum of Natural History (AMNH), the first author decided to field test their Five Tools and Processes for Translating the NGSS into Instruction and Classroom Assessment, Figure 3, within the course. Piloting the AMNH tools necessitated strict fidelity to their implementation guide. This meant spending more time on the structure of the NGSS and less time on curriculum change.

Figure 3 (Click image to enlarge). Five tools and processes for translating the NGSS.



Course Design

The overarching three phase structure of the course remained the same, though time allocations changed substantially. The required textbooks for the course remained the same as course version 1.0. Due to the time spent piloting the AMNH tools, the historical perspective of science curriculum change was shortened to one week. This involved omitting The Science of Common Things and drastically reducing the discussion of the Bupp change curve (1996) and 20th century science education reform. It was occasionally awkward to use someone else's pacing guide but on the whole the teachers did very well.

After we were done with the AMNH tools we moved to the scope and sequence project, omitting the requirement of Common Core alignment from the project directions. Experiences in the first version of the course led the first author to seek out targeted help from members of the professional community. This included inviting the second author to share an example

of a scope and sequence aligned to the NGSS which corrected the lack of exemplars encountered in the first version of the class. She was able to offer feedback to the teachers on their projects and, due to her background in instructional design, served as a resource for writing learning objectives.

Lessons Learned

The AMNH tools were preparation intensive and sometimes cumbersome for a single facilitator. Of the five tools, the first and third tool were most appropriate for the course. The most common feedback from the teachers was that we spent too much time on the tools and they would have liked to spend more time on their own scope and sequence.

The first AMNH tool teaches the concept of bundling, in the context of a middle-level unit on ecosystems. This includes DCIs, PSEs, CCCs, and connections to Common Core, nature of science, and engineering, all centered on a common storyline. Building bundled units piece by piece is a powerful teaching method. The structure that exists within the NGSS is markedly different from the content-focused RI GSEs that were designed to be taught sequentially and in isolation.

The third tool is about building units and employs the 5E method to teach three-dimensionally. While most of the teachers had heard of the 5E method, few knew it well and very few used it as their sole method of building units. Comparing the traditional teacher to one who uses the 5E model helped illustrate how classrooms would change under the NGSS. The materials introducing the 5E method were quite clear and easy to follow.

Version 3.0

The third version of the course ran in the fall of 2016 and the second author was invited to serve as the teaching assistant. We revised the class again, keeping AMNH tools one and three, and reintroducing the Science of Common Things and the Teaching Gap into the readings. The time was again redistributed, and ended up where it had originally been. Again, the required textbooks remained unchanged.

Having conducted the course twice using different methods and materials, the authors felt that we were approaching the final version of the course. Lessons learned in the two previous iterations, along with course evaluations from teachers, guided making improvements. The discussion of the history of change in science education was helpful for teachers to situate the transition to the NGSS into a context of other curricular changes. Teachers, through course evaluations, requested more time for the final project, thus it was necessary to reduce the time spent on the NGSS tools.

Course Design

Again, we maintained the three-phase structure that had been used in the previous two versions of the course. To accommodate all of our goals we expanded phase one, contracted phase two, and introduced the final project earlier in the semester. This allowed us to use the time spent with the tools in phase two to help teachers begin to construct their final project.

Phase one in this iteration of the course largely returned to the structure followed in version 1.0. We kept the same emphasis on modeling three-dimensional instruction though it began earlier in the semester. More emphasis was placed on the Bupp change curve (1996) as we were able to incorporate it from the very beginning.

The second phase of the course represented a melding of the previous versions. Tools one and three from AMNH along with the four circles activity and the close read of appendices F, G, and K formed the curriculum. Significant time was spent on the four circles activity as it served as the lens through which we looked at appendices F and G. The 5E model was discussed in detail and teachers were instructed to design a 5E unit plan based on their current curriculum. This assignment helped familiarize teachers with 5E instruction and served as an example for their scope and sequence.

The final project for the teachers was a full-year scope and sequence including the following: one-third of the standards for their grade band, defined units of study based on bundled performance expectations, measurable and observable objectives, alignment to the 5E model, and a reasonable timeline of instruction. An example can be found [here](#).

Lessons Learned

Teachers continue to notice that the NGSS build from K through 12 and high school teachers are reliant on the work of middle and elementary science educators. Committing to the NGSS therefore requires a trust in others' work which some teachers lack. Another comment, looking in the opposite direction, was that while the NGSS would be an effective way of increasing science literacy, a mismatch between the outcomes specified by the NGSS and faculty expectations of content knowledge at the college level would make college science classes difficult for students.

Other concerns raised by the teachers included system capacity to implement these changes, especially the need to strengthen elementary science education. Earth and space science education is not an area of certification in our state and coursework in Earth and space science is not required, by the state, for any certification. As science teacher educators we continue to advocate for changes in state-level certification policy and provide resources to teachers who wish to develop their content knowledge.

Reflections and Conclusion

First Author

The changes made to this class have improved the students' ability to explain the context for curriculum change, the goals of the NGSS, and the impacts on classroom practice. The content of the course remains a heavy load for practicing teachers; our goal is not to merely inform, but to change a teacher's classroom priorities and practice. This is a shift of professional identity. Moving to less familiar methods and curricula could mean a decrease in effectiveness for some teachers.

While it came as a surprise originally, introducing the Bupp change curve (1996) gave teachers license to discuss their emotional reactions to those changes while providing them with a structure to understand and conceptualize their feelings. A change of this magnitude would be stressful for teachers even at the best of times. The NGSS represent a more profound change than many of our teachers initially realized. Coming as it does in our state, on the heels of other stressful changes such as pension reform, adoption of the Common Core, and changes to the teacher evaluation system, some teachers view the NGSS as professionally threatening. A fully aligned curriculum means changing content, pedagogy, and even the purpose of science education.

I have tried to make it clear to teachers that curriculum conversion is a slow process, and both AMNH tool one and the four circles activity emphasize that much of what teachers currently do will remain part of their practice. Tool three, several of the readings, and the scope and sequence final project all emphasize tradeoffs, but some teachers are reluctant to let go of any scrap of content. This holds true even as they examine less-than-great state science results and admit that more needs to be done with regard to science literacy and practice.

One teacher had trouble including waves as content in his chemistry course. As he said "they are important but really, that's physics". The response that was persuasive was "many of the tools of the modern chemist, like spectrophotometers, are based on waves and students need to understand how their tools work". Other arguments had failed because this teacher identified himself as chemistry teacher and not as a science teacher (Paechter, 2002).

I am still concerned about the upcoming assessment; a poor-quality test could imperil the new standards, as the PARCC test did for the Common Core. Our state has dropped the PARCC in favor of the SAT at the high school level and is in the process of developing a Common Core-aligned assessment for the elementary and middle grades.

Interestingly, one of the patterns that emerged over the three versions of the course is that teachers from private schools and non-NGSS states are more willing to take innovative risks with their scope and sequence projects. The most innovative student produced a scope and sequence centered on natural disasters and preparedness. In addition to learning about extreme weather conditions, units also focused on first aid, the requirements to support human life, and signaling. This course, designed as an elective, was built to be interesting to

students and featured a very strong use of backwards design (Wiggins & McTighe, 2011). Course evaluations have been quite strong across all versions, ranging from good to excellent. While we cannot draw conclusions with statistical certainty, this phenomena is unlikely to be a coincidence.

Second Author

Long-term engagement with a course from a variety of perspectives has been an interesting, valuable, and unique opportunity. During the first version of the class, I was a graduate student. In the second, I was the example for the scope and sequence final project and guest assessor. I was asked to be the teaching assistant for the third version of the class, and then participated in the reflection that created the final version we are discussing here (included below). If needed in the future, I may even teach this class as an adjunct faculty member.

Participating in the process of course design, reflection, and re-design has been fascinating. When I was a student in the course, I was largely concerned with what was contained in the NGSS and how it would be implemented in my school. I have since served as the author of the NGSS-aligned biology curriculum for my school district. Conversations with my fellow faculty members have led me to believe that a large number of science teachers are resistant to the NGSS. Some of my colleagues stated that we would be on to the next sweeping change in pedagogy before long, meaning that the NGSS would amount to little more than a series of grand pronouncements, accomplishing little.

Given the concerns of my colleagues, and the poor performance that the students of our state have had on Earth and space science material in the past, I decided to write a scope and sequence for a high school-level Earth and space class. Our current model of teaching Earth and space science topics is to divide them up among Biology, Chemistry, and Physics, where they are every teacher's least favorite topic and the one most poorly supported by resources. Years ago, there had been a determined effort to move Earth and space science entirely to the middle school. The test aligned to the pre-NGSS science standards has been a clumsy compromise between three states with different science curricula and different teacher certification policies.

Conclusion

We have learned that in order to go beyond the common, single-intervention professional development model, attention must be paid to the emotions of the participating teachers. Curriculum change is a complex process and, in this particular case, the shift to the NGSS is a change in content, delivery, and purpose. It changes what it means to be a science teacher and mid-career professionals benefit from support as they work through these changes. We are pleased with the results of this revised class and are happy to see that most of our teacher participants have made significant strides toward the NGSS. Teachers from this class were selected to rewrite the curricula for several districts. Additionally, teachers have

presented at state and national conferences on the NGSS, including presentations on shifting to 3D instruction, challenges in curriculum design for the NGSS, and integration of the NGSS with the Common Core State Standards. The course has also generated the beginnings of a community of practice across schools where teachers can share ideas and support each other in the transition to the NGSS.

The NGSS are a profound shift in science education and the professional curriculum development industry is still in the early stages of producing aligned materials. This leaves curriculum writing to teachers who have little experience with this work as it has been largely moved out of the hands of K-12 public school teachers in our state. One teacher described this challenge as:

I know that curriculum should be designed around student performance expectations, not a collection of disjointed factual information. That's good. I know science and engineering practices, core ideas, and cross-cutting concepts are built in to the performance expectations—so that ultimately, when designed thoughtfully, assessments will measure student progress in all three. (also good) I know that there are a variety of ways to assemble a curriculum, and that teachers are being trusted with this responsibility. (also good) I know that design of effective instruction and assessment takes time and effort. This stuff is not quick and easy, but with practice I think the process will run more smoothly as time goes on.

Providing significant support for scope and sequence writing was essential. In hindsight, both authors had experience teaching in Catholic high schools where curriculum writing was an expectation and they developed proficiency with the required skills.

Providing teachers with concrete examples of NGSS-aligned instruction that they were allowed to experience from the perspective of a middle or high school student was critical. Inquiry has been more of a buzzword than an enacted pedagogy in many science classrooms. Three-dimensional instruction goes beyond inquiry and, as a concept, requires time and experience for teachers to grasp. In a final course evaluation one teacher stated:

I will think 3-dimensionally about the work addressing the performance expectations. I will look for cross-cutting concepts which appear between disciplinary core ideas and will look for opportunities to integrate scientific & engineering practices. By using the Performance Expectations, I have developed a scope and sequence which will allow a more investigative and student-centered learning approach. The days of 'death by powerpoint' are coming to an end!

It remains to be seen if there will be a clamor for professional development once scores are available from the new NGSS-compatible test from American Institutes for Research. If there is, we have a class that is ready for students. The class should be effective for teachers who are 'non-volunteers', but the opportunity to collect that data has not yet arrived.

Supplemental Files

[Syllabus.docx](#)

[Sample-Student-Scope-and-Sequence.docx](#)

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