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Building momentum by starting small

Cassandra R. Seiboldt,
Northeast High School, Lincoln, Nebraska., cseibold@lps.org

Lorraine Males
University of Nebraska-Lincoln, lmales2@unl.edu

Joshua R. Males
Lincoln Public Schools, jmales@lps.org

BUILDING M

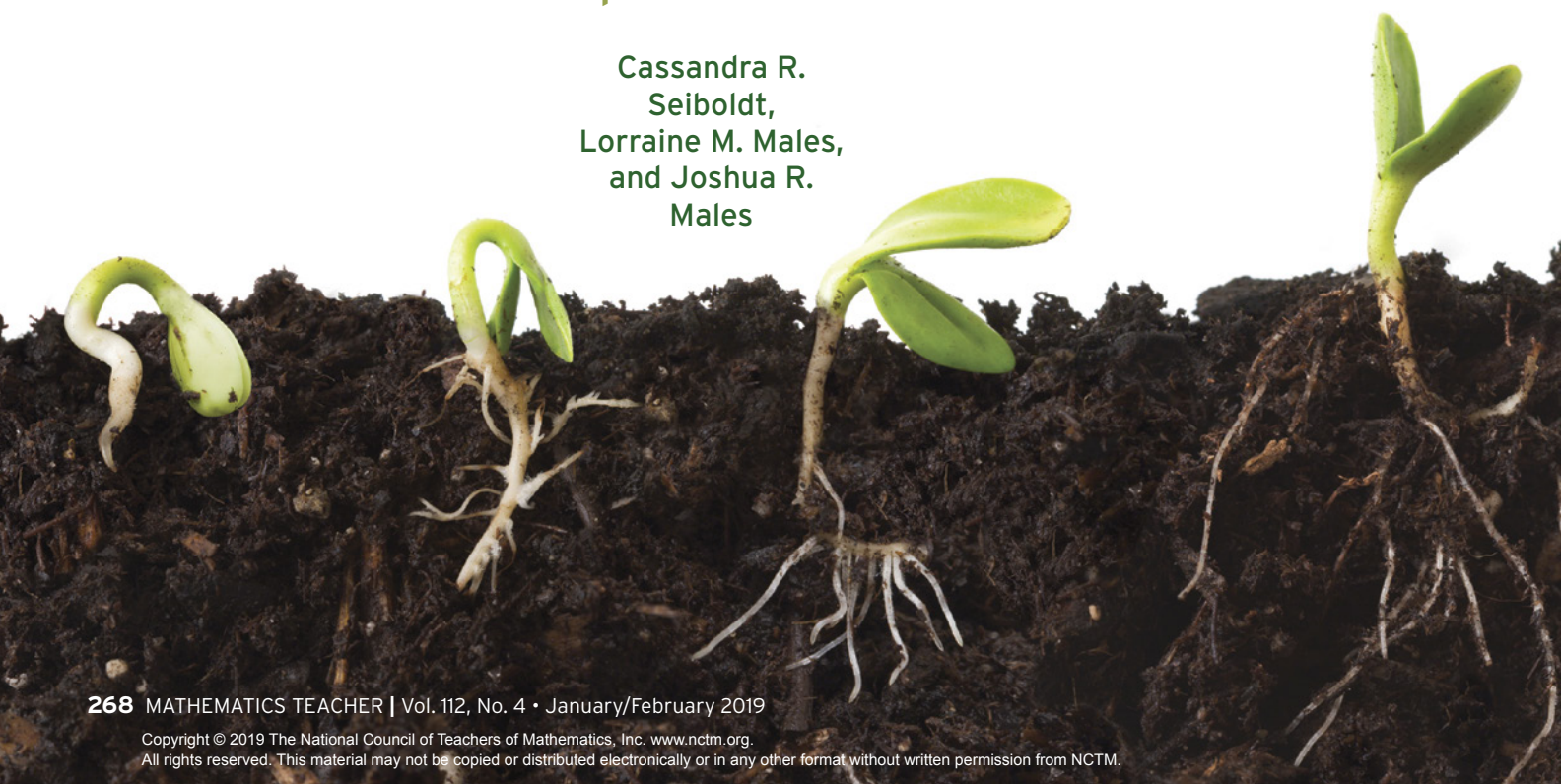
A university mathematics teacher educator and a math department chair reflect on how various assignments and structures can support early-career teachers in anticipating student thinking and solutions to purposefully plan lessons.

Cassandra R. Seiboldt, Lorraine M. Males, and Joshua R. Males

Beginning a teaching career and working to prepare and support beginning teachers is a roller-coaster of successes and puzzling moments. In this article, author Cassandra (Cassie) Seiboldt shares how she learned to manage her first years of teaching by purposefully planning through anticipating student thinking and solutions, and the positive impact this had on her instruction. Lorraine Males, Cassie's university mathematics teacher educator, and Joshua Males, Cassie's mathematics department chair, reflect on how various assignments and structures may have supported her in the lesson-planning process.

SEIBOLDT: SETTING GOALS

When I began my first year of teaching, I thought I felt well prepared for the challenges I was about to face, but I did not realize the different struggles I would have being a new teacher. One of my biggest fears as a beginning teacher was that I was not going to be able to do everything perfectly



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right away on a daily basis. Overwhelmed with the amount of work that teaching created, I knew I needed a way to organize myself so I could improve my practice. During one of my first work days before the beginning of the school year, the district curriculum specialist for mathematics explained that whenever teachers start something new or try to change a norm, they must "start small, build momentum, and persevere" (Larson 2014). I had not established my teaching norms quite yet, but I knew that this idea could provide me with a framework I needed for improving my practice. Reflecting on my experiences from my teacher education program and student teaching, I decided to take our curriculum specialist's advice and set a goal to build momentum in anticipating student solutions during planning so that I could lead productive discussions in the classroom. By focusing on this goal, I enacted small changes in my planning and preparation that led to big impacts. In the next sections, I describe the goal, and my university methods instructor and department chair share their thoughts on how they supported my work in the area of planning and preparation.

Goal: Anticipate Student Thinking More When Planning and Preparing

During the summer months, I was given the curriculum materials and course outlines provided by the school district to help begin planning units and individual lessons. I was familiar with the mathematical content of the precalculus course objectives and standards for the district because I had assisted in teaching the same course during my student

teaching experience. I was unfamiliar with the geometry topics I needed to address because I had not observed or assisted in a geometry classroom during student teaching. To begin planning, I first spent time working through the geometry textbook to understand the progression of topics. Once I felt comfortable with my knowledge of the geometry and precalculus content, I began to create timelines for units and assessments.

After the school year began, I started planning day to day by choosing mathematical tasks and adjusting each task as needed. To plan my mathematics lessons, I used the 5E instructional framework (Bybee et al. 2006) adopted by my district. This constructivist framework includes five phases: engage, explore, explain, elaborate, and evaluate. As a set, these phases work to support teachers in designing lessons to help learners build on their own ideas to learn new ones.

At the outset I was extremely persistent in planning lessons in detail using something similar to the Thinking through a Lesson Protocol (Smith, Bill, and Hughes 2008) or TTLP, which we had used in my methods course. But as the academic year began, I was having difficulty managing my time dedicated to planning. The time set aside to plan began to fill with grading, responding to emails, and assisting students one-on-one. I would begin to create or adjust tasks to fit the needs of my students and not think deeply enough about enacting the lessons. This showed in my teaching: Discussions were difficult to lead, and I had numerous moments where I was uncertain of what to ask students to support their mathematical understanding. My questions were created in the moment, and I had difficulty assessing and advancing students' understanding.

I realized that I began to experience more uncertainty in the classroom because I had not taken time to think about possible student responses and solutions for certain mathematical tasks. From my experience planning multiple lessons in my teacher preparation program using the TTLP, I knew that to have more productive discussions and reach my lesson objectives, I needed to anticipate what students would be doing, saying, and asking. I knew that I had to anticipate more than just the correct answers to certain mathematical tasks in my 5E lesson plans. If my students were exploring a mathematical concept, I needed to be able to predict what students might say or do in response to certain tasks.

I decided to set a goal for myself to make anticipating student solutions a top priority. To achieve my goal, I set aside time every day to write out all possible student solutions or ways that they would approach the tasks in my lessons. I also wrote out the questions I would ask during discussion and what students might answer in response to these questions. To gain additional perspectives, I asked my colleagues which student misconceptions might arise. I saved all my anticipated solutions and questions with my 5E lesson plan in a binder in my classroom to help guide me if I was unsure what to ask students next.

Some lessons required more time to anticipate student solutions than others. One such topic in precalculus is graphing sine and cosine functions. I wanted to make sure my students engaged in a meaningful task that would encourage developing a deep understanding of the sine and cosine graphs to lay the foundation for later topics. To support this, I researched several ways to begin teaching the topic, and during my research, I came across a promising NCTM Illuminations lesson. Graphs from the Unit Circle (NCTM n.d.) is a task in which students use the properties of the unit circle to create the graphs of the sine and cosine curves. Students create the graphs using uncooked spaghetti to show lengths from the unit circle to plot coordinates for both $f(x) = \sin x$ and $f(x) = \cos x$.

While planning this lesson to use with my own students, I began to complete the task independently, using only the student instructions and materials. Although I found this extremely difficult to do, I tried to take a learner's stance when approaching the task, similar to what my students would experience. During this process, I wrote down things I was noticing and wondering as if I were a student. After completing the task and taking notes, I referred to the instructional plan to see whether any supports were given that might address my initial list of questions and if there were suggestions on how best to facilitate the task. I continued to collect notes and ideas on what I could anticipate while enacting the lesson.

To gain additional perspectives, I asked the mentor assigned to me through my district's mentoring program for additional support. I felt comfortable sharing that I was struggling with anticipating my students' responses and solutions to tasks and what questions I could ask to clarify their understandings. During our professional learning community

PREVIOUS SPREAD & LEFT: KATELEIGH/GETTY IMAGES

Table 1 An Excerpt from the Explore Phase of the Lesson

	Task	Anticipated Student Solutions/Misconceptions	Actual Student Solutions/Misconceptions
Explore	Teacher moves during task: • Circulate to each group • Clarify directions • Select and sequence student statements or solutions for whole-class discussion.		
	"Transfer the marks on the string onto the x-axis of the function graph. The end of the string that was at 0 radians must be placed at the origin of the function graph. Label these marks on the x-axis with the related angle measure from the unit circle."	Students may struggle with labeling the x-axis in increments of π. Students may confuse the x-values on the function graph with the x-values of the coordinates on the unit circle. They may also confuse x and y values; they need to use y-values in order to graph the sine function.	Three of eight groups questioned what the independent variable was for the graph of the sine function. I helped several groups talk about inputs/outputs in terms of the graph we were creating.
	"Which component from the unit circle do the x-values on the function graph represent?"	Students may choose to think of the independent variable as cos x instead of x radians.	Five of eight groups were able to determine that the x-values on the function graph represented the angle measure in radians.
	"Break a piece of spaghetti to the length of the vertical leg of this triangle, from the $\pi/12$mark on the circle to the x-axis. Let this piece of spaghetti represent the y-value for the point on the function graph where $x = \pi/12$radians. Place the spaghetti piece appropriately on the function graph and make a dot at the top."	As students continue this process into quadrant III on the unit circle, students may not place the vertical height below the x-axis.	Two of eight groups needed further discussion about placing the vertical height on the graph as the angles moved to quadrant III. I prompted students with questions about coordinates of points on the unit circle with a negative y-value

meeting, I shared the task with him, and he offered feedback on my notes and the questions I had created to support the lesson. He added additional misconceptions for the sine and cosine graphs for me to investigate further for this particular math task.

Tables 1 and **2** include an excerpt of my lesson plan, specifically the "explore" and "explain" sections, including anticipated responses with notes on which student misconceptions actually happened.

While enacting each lesson, I found that my anticipation paid off. I noticed that some of my anticipated solutions were shared by students, and when they were, I was better prepared to select and sequence their solutions to be presented to the whole class. I had already determined the key discussion points I wanted students to make in their presentations. If a student provided a solution that I did not anticipate, I recorded it in my notes to document it for future iterations of this lesson. If students did not think of ideas that helped reach the lesson objectives, I would ask some questions that focused students' ideas around the general characteristics of the graphs. Although I could not foresee every solution a student would suggest, I felt that the lesson was more productive in reaching the learning objectives because I was more confident in predicting what my students might say or do in reaction to the task.

LORRAINE MALES

Reflection: Supporting Lesson Planning That Focuses on Student Thinking and Coherence

Reading Cassie's reflection on this goal reminds me of two important topics addressed in our methods class: learning to plan lessons that build on student thinking and learning to read curriculum materials. Cassie clearly values engaging students in discussion; however, what strikes me is that she understands that discussion can, in fact, be planned for. By deemphasizing teaching as an improvisational activity (Stein et al. 2008), I aim to support prospective teachers in learning to use student thinking productively in discussion. Lesson planning is a staple of many methods courses; however, I intentionally choose to have students both plan and enact these lessons in our methods class. Although planning lessons can be an educationally worthwhile activity in and of itself, I contend that unless the plan is enacted, the ability to see the value in and understand the benefits of purposeful planning cannot be fully realized. Enactment of the lessons serves as a rehearsal (Lampert et al. 2013) that provides teachers with the opportunity to see the value

Table 2 An Excerpt from the Explain Phase of the Lesson

	Discussion	Anticipated Student Solutions/Misconceptions	Actual Student Solutions/Misconceptions
Explore	After students complete sine and cosine graphs and answer questions about graphs, choose three sets of partners to present sine and cosine graphs in the following order: 1. Sine Graph Characteristics 2. Cosine Graph Characteristics 3. Comparing the two graphs		
	Lead class discussion by asking • How can we describe these graphs? • How are the sine and cosine graphs similar? How are they different? (If anticipated student responses do not arise, ask prompting questions to examine more characteristics of sine and cosine graphs.)	• Repeating/Cycles (Periodic) • Period is 2π • Domain is all real numbers for both sine and cosine graphs • Range is $-1 \le y \le 1$ for both sine and cosine graphs (maximum and minimum). • x-intercepts for sine graph: $0, \pi, 2\pi, \ldots$ x-intercepts for the cosine graph: $\pi/2, 3\pi/2, 5\pi/2, \ldots$	• "The graphs have hills and valleys." • "They both repeat their pattern at 2π." • "They have a maximum at 1 and a minimum at –1." • "Both graphs repeat the same pattern." • "They are both smooth." • "They make the same shape, but they aren't the same graph." • "The graphs show us traveling around the unit circle." • "One graph is just shifted over a little to the right." • "Both graphs are functions."
	Complete Match = ——→	**Partial Match =** ——→	

of anticipating as they work to interpret and respond to student thinking in the moment. I adopted the TTLP (Smith, Bill, and Hughes 2008) as a structure for lesson planning because it provides a lesson framework that focuses on using students' thinking and reasoning. Providing Cassie with this TTLP structure enabled her not only to learn to plan a lesson but to value and plan lessons that draw on student thinking by focusing on anticipating it. When in her own classroom, Cassie noticed that when she did not intentionally set aside time to anticipate student thinking, she struggled to lead discussions. She did not have questions prepared to assess and advance student thinking because she had not thought about student thinking.

Another key aspect of our planning and enactment activities was that we did these activities using standards-based curriculum materials, or materials written to align with NCTM's (2000) *Principles and Standards for School Mathematics*. What strikes me about Cassie's initial use of her materials that may have been supported by her work on this assignment is that she went beyond using the textbook as a source of exercises or problems for students and directions for herself (Stein, Remillard, Smith 2007). Instead, to develop an understanding of the progression of topics, she worked through the curriculum materials before she began teaching. Rather than remaining "text bound" (Ben-Peretz 1990) and using the textbook as a source for what to do, Cassie examined the progression of content and used this knowledge to develop timelines for instruction and assessment. She did not assume that she could just teach from this text every day and provide her students with a coherent set of mathematical experiences. This is further exhibited by Cassie's selection and adaptation of tasks to meet her goals. The lesson she describes in this article is an example of how her critical examination of her textbook spurred her to look for something more meaningful that would engage her students more productively.

JOSHUA MALES

Reflections: Anticipating New Teachers' Struggles and Setting Up Supports for Planning

One way to help alleviate beginning teacher stress and reduce their feelings of being overwhelmed is to build a schedule that will add supports throughout the semester. Creating a schedule is never easy, and adding new members to a department makes this yearly task even more challenging. My goal was to balance the existing department members' desires, to have someone teaching each course who had taught the course in the past, to limit the number of courses each beginning teacher has to prepare for, and to draw on the beginning teachers' student teaching experience. The first year of teaching offers enough challenges; I think that limiting the number of preparations for a beginning teacher and having the chance to teach at least one course in which they have had some experience can reduce some of the pressure. Assigning Cassie

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Seiboldt to teach precalculus, a class that she had taught during her student teaching, may have provided her with the comfort and confidence to seek out more meaningful experiences such as the one that she describes above.

Another way in which I attempt to support beginning teachers is by providing them time to think about and plan for their classes in advance. I always meet with all the beginning teachers as a group early in the summer. Although I cannot expect them to spend their entire summer planning, I realize that new teachers are excited to get started planning and thinking through how their classrooms will operate. In this initial meeting, I supply them with the curriculum materials, course outlines, and some general information about what they will be teaching. I also use this opportunity to let them know that I expect them to have questions throughout the year, that they may have to ask about some things multiple times, and that this is not unusual. The real goal of this early meeting is letting new teachers know that we are all in this together and that I am here to support them in any way that I can. From reading Cassie's reflection, this initial meeting clearly allowed her to get started planning with the curriculum materials and course outlines early and that she did, in fact, feel comfortable asking questions, as she notes going to her mentor for support.

Finally, I have found selecting mentors for beginning teachers to be one of the biggest challenges in supporting them. Ideally, I would know the beginning teachers' personalities and have the perfect experienced teacher with whom they could work in their first year. Using reference letters, the interview, and conversations throughout the summer, I try to do the best I can to find a mentor to whom they can relate and from whom they can learn throughout the school year. Clearly, Cassie felt comfortable sharing her struggles with her mentor. This mentor not only served as a colleague who could answer her logistical questions but also was committed to supporting Cassie's planning as evidenced by his willingness to draw on his vast teaching experience to provide her with support in anticipating student thinking.

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CASSANDRA R. SEIBOLDT, cseibold@lps.org, is a mathematics teacher at Lincoln Northeast High School in Lincoln, Nebraska. Her interests include how teachers effectively collaborate in lesson planning and instruction. **LORRAINE M. MALES**, lmales2@unl.edu, is an assistant professor of mathematics education at the University of Nebraska–Lincoln, where she works with secondary prospective teachers and mathematics education graduate students. She is interested in how teachers learn to use mathematics curriculum materials. **JOSHUA R. MALES**, jmales@lps.org, is the K–12 Mathematics Curriculum Specialist for the Lincoln Public Schools. He works with teachers to improve classroom instruction and is interested in systematic change in mathematics education.