

## HOW TEACHERS LEARN: THE IMPACT OF CONTENT EXPECTATIONS ON LEARNING OUTCOMES

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During the past seven years, the mathematics community in Virginia has been developing and offering programs to prepare teachers to serve as Mathematics Specialists/coaches and to devise means to support these Specialists as they assume their roles in the schools. We have received substantial support from the National Science Foundation to develop and offer these programs and to conduct research on their impact.

Upon the completion of these projects in December, 2009, the primary investigators hosted the “What We Have Learned Symposium.” The goal was to provide an opportunity for various collaborators to share their findings and observations from their different vantage points and areas of responsibility within the program. The Symposium consisted of discussion panels that were crafted to extract the collective experiences of four distinct groups: mathematics supervisors involved in the aforementioned program, Mathematics Specialists who had participated, instructors of the leadership courses, and instructors of the content courses. As a member of the latter group, I was charged with answering the following question:

*What did you learn about the abilities/interests/background/attitudes/expectations of the teachers in the preparation program?*

In forming an answer to this question, I gravitated toward the “expectations” part of the statement and began to reflect on my first impressions of the participants in the *Probability and Statistics* courses that I taught. I should first say that, as a college professor of six years, my experience with K-12 teachers has been limited to my participation in this project. Moreover, outside of undergraduate instruction, this was my first opportunity to serve math teachers in the capacity of primary content instructor. In doing so, I quickly learned that, at least initially, many participants in the program had seemingly low expectations for learning new material from the content courses of the program. This may seem like an odd assessment at first. However, it is necessary to keep in mind that: 1) the nature of the program is to recruit and prepare some of the most talented and motivated K-12 teachers; and, 2) the course content is K-8 based. It is then

more understandable that many participants were not lured by the opportunity to learn new content. Rather, it is more likely that many were primarily lured to the program by the opportunity to either gain licensure as a Mathematics Specialist or to obtain a master's degree. In other words, my presumption is that participants began the program with a high level of confidence in their knowledge content, whether justified or not. The reason this is significant is that it can conceivably make the learning environment quite different than the typical college course setting where students begin most courses with *no presumption* of understanding all (or even most) of the material that is to be presented.

### **Meet Jane Doe**

Consider the following scenario as an example of the challenges that an MSP participant may face with respect to having a shift in learning expectations. Jane Doe has been selected to participate in an MSP program by virtue of her recognized excellence in the field of teaching and coaching other mathematics instructors. To her, the program has been presented as a mix of content and leadership courses that “include new content, focus on developing content across multiple grade levels, and seek to develop teachers’ pedagogical content knowledge for teaching.” Jane gleefully agrees to participate in the program. However, being unofficially labeled as one of the top teachers in her district, she has little or no expectation of gaining new *content* knowledge from this program. Instead, she focuses on the latter parts of the program description, and figures that the program will simply deepen her ability to convey the material to her colleagues once she is hired as a Mathematics Specialist. Let us now fast-forward to the third day of her first content class. Here sits Jane Doe, in the front of the class, realizing for the fourth time in three days that her knowledge of the concepts she *thought* she knew at a mastery level (and had taught for four years to students and colleagues alike) was shallow, at best. As the instructor continues the lesson and conversations ensue throughout the classroom, Jane sits silently and thinks to herself, “Wow. I never knew. How many times have I taught this concept incorrectly?” While the class pushes forward with the lesson, intertwining the concepts just presented with methods and thoughts on *how to teach the concepts to teachers and students alike*, Jane has shut down and will most likely be left behind. When and if she catches up to the rest of the class, it is conceivable that her focus will now be limited to trying to grasp the mechanics involved in the lesson and figuring out how the new ideas mesh with her prior knowledge.

Significant research has been done regarding how a classroom teacher’s expectations of student achievement affect (and essentially mold) the learning experience for the students involved. However, in this case, we are considering the expectation of the participant’s own learning; and more specifically, how the possible disconnect between expectations and reality can affect the learning outcomes. In short, Jane Doe’s hypothetical experience raises the question:

*How does the need to learn (or in most cases, unlearn) content material affect the overall learning experience of a MSP participant who may not have had such expectations prior to starting the program?*

Simply put, my hypothesis is that encountering this disconnect between “what I know” and “what I thought I knew” can be hindering for the remaining parts of the learning process. Initially, it often takes time for the participants to properly redefine their definition of “knowing” the mathematics. A mindset that I’ve typically encountered can be best summarized by the statement, “I can do it, but I don’t know it” which refers to most participants’ ability to complete the procedural portion of the mathematics without an adequate understanding of why, how, or even when the given procedures are applicable. If the course is successful, then what they eventually learn is that such an understanding of the mathematics is not a complementary aspect to what they would call content knowledge, but in fact *is* the content knowledge itself. It is this revelation that often shines light on the participants’ content knowledge deficit, and allows them to successfully move forward in the learning process. However, I have found that for some, recognizing the need to push past the doing to the knowing can be a long and painful process, to the point where it impedes their ability to embrace the learning experience and absorb the full value of the lessons at hand. This is what I term the “Jane Doe Experience.”

### **Redefining Content Knowledge: The Histogram Example**

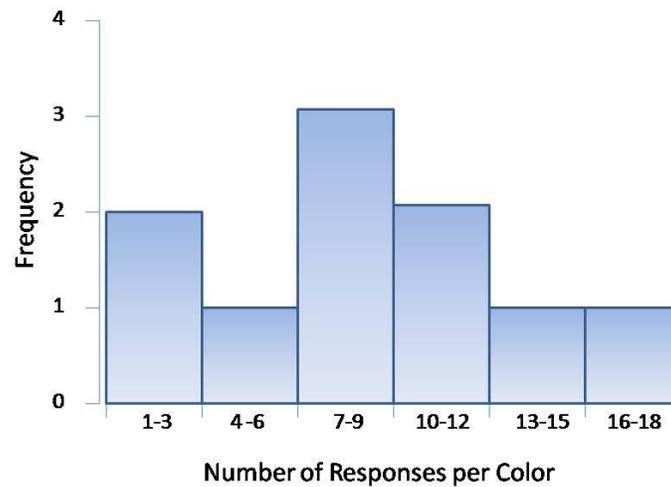
Consider the following example which, at least in its general form, took place during the presentation of an assignment during *Probability and Statistics*. A group of three participants were given the task of creating an experiment, collecting data, and choosing a graphical representation to display the data. To complete the first part of the assignment, the group chose to address the question, “What is your favorite color?” There was a fallacy in this part alone, as the data resulting from this query would not result in a continuous (versus discrete) data set as was required for this particular assignment. Nonetheless, the group collected the data (see Table 1).

**Table 1**  
**Results of Group Data Collection**

Color	# of responses
Black	7
Blue	18
Brown	2
Gray	8
Green	10
Pink	7
Purple	10
Red	15
White	5
Yellow	1

To complete the assignment, the group chose to work with a histogram, and displayed their data (see Table 2).

**Table 2**  
**Color Histogram**



The trouble was, at a glance, few participants could see the fallacy of this setup. On one hand, the group that presented this display clearly knew the mechanics of creating a histogram as it is presented in any mathematics textbook. That is, they understood the things that may have

been considered histogram “content knowledge” prior to the course. Moreover, one of the participants even mentioned the vague resemblance to a Normal distribution which did suggest some level of understanding of the usefulness of such graphs. However, what was lacking on both accounts was the understanding of the parameters in which a histogram can be applied, and how to garner a proper interpretation of the graph. These are two points that are arguably far more important than the procedural aspect of the lesson. To get the participants to see the fallacy of applying this graph type to this data set, the instructional team was careful to pose questions that did not suggest that the usage of this graph was incorrect. Rather, we framed the questions with the hope that the participants would reach this conclusion on their own based on their inability to properly interpret the graph. In the end, we were largely unsuccessful, even though no one could successfully answer the question, “what does this graph tell us about favorite colors?” (to which the answer is “essentially nothing”). Few could pinpoint the reason why the question (and lack of an answer) was important. That is, it was not made evident that this was the wrong choice of graph for this scenario. Moreover, as we pushed forward with the lesson and discussed the context in which a histogram is applicable and useful, and the resulting interpretations—evidence of the “Jane Doe Experience” began to materialize.

### **Conversations with Three Mathematics Specialists**

With the Jane Doe Experience, the Histogram Example, and my initial hypothesis in mind, I followed up the Symposium with interviews of three MSP participants. The hope was to gain further insight into the expectations of participants with respect to learning, and the subsequent effect (if any) of those expectations. The manner in which the interviews were conducted was by no means scientific in nature. They were conducted in the form of a conversation, during which the participants were asked questions with the hope of leading them toward this subject without biasing their responses. At the end of the interview, they were then presented with the premise of the interview: namely, the italicized question in the section entitled “Meet Jane Doe.” They were then blatantly asked to agree or disagree with the hypothesis. What follows is a brief description of each interviewee’s teaching background, followed by the transcription of some of the responses collected, and a suggested model for teacher learning. Lastly, please note that the three participants were not all interviewed together, and therefore the sequence of excerpts presented here should not be construed as the exact sequence of the conversations that took place.

Throughout this article, I will refer to the three interviewees as Participants 1, 2, and 3; or simply, P1, P2, and P3. Of the three, P1 was the most experienced, having taught for fourteen years. She is preK-4 certified, and has taught third grade for eleven years. With six years of experience and preK-3 certification, P2 has been a classroom teacher for first, second, and third

grades. Participant 3 has also taught for six years, but previously spent an additional four years as a substitute teacher. As a full-time teacher, she has taught fifth grade exclusively and is preK-6 certified.

In each case, the first part of the conversation was centered on determining how each participant was recruited for the program. The goal was to determine when they were told about the content involved in the courses, and how the delivery of this information began to shape their expectations of the program. Here are their responses.

- P1: The Senior Math Coordinator for my school district told me about the program. I had just become a Math Resource Teacher. She mentioned that it would be three summers and a few leadership courses, but that's about all I knew initially.

Participants 2 and 3 had very similar accounts. Each was told that the program would last three years and that a certification or licensure (which was not yet approved) would be involved. Participant 2 was quick to point out that a list of courses was not given, while P3 mentioned that she knew little about what would be involved besides the opportunity to be a Math Resource Teacher at the end of the program. From here, the question was asked, "So when did you find out more about the courses that you would be taking?"

- P3: I didn't find out anything else until I walked in the door [of the first class]. We did take a pre-test [prior to the start of the program], but for some reason I didn't think that the pre-test related much at all to the courses that I would be taking.
- P2: I remember that we went to take a pre-test downtown. Dr. McNeil (one of the Norfolk State University professors) was there. At that point, we learned more about the program and we also took the pre-test for the first course and were told to take the GRE. [In terms of the pre-test], I didn't think much of it. There was a lot of stuff on there that I didn't know, but I just thought to myself, "I must have forgotten all of this"; but, I wasn't overwhelmed. I figured it would all come back once I got into the class.
- P1: At some point before the classes started, I found out that [the program] was about K-8 certification. And I knew the subjects [that would be covered]. I remember thinking, "Okay, I know those." I was more curious as to how they were going to show me this "new math" and how I was going to adapt to it and be able to relay it to my students. I was told that it wouldn't be the usual procedural stuff, but I was skeptical. At that time, there was little thought about the content.

The comments of Participants 1 and 2 are consistent with the premise that, for at least some participants in the program, the focus was on pedagogy and the level of expectations for learning new content was low. In fact, prior to the program starting, all three interviewees seemed squarely focused on the extent that the courses would build upon pedagogy and leadership skills. Little thought was put toward the extent that they might be challenged by the content involved. Along those lines, Participant 1 also added that she had already taken courses at the master's level and had simply thought, "How hard can it be?"

With this established, each conversation was then shifted toward the interviewee's personal assessment of what was learned versus the aforementioned expectations.

- P2: *Numbers and Operations* was the one class [in which I felt] I knew the material beforehand. All of the other classes were me learning the math [for myself]. I struggled more with the content of the other classes. I think it was the same thing for [two other participants]. With this class, I knew the content and [so I was able to] go deeper with it. But with the others, it was more figuring out the meaning of the math. For me as a learner versus as a teacher, it took an adjustment. First I had to realize that I'm not stupid. [...] It helped that other people struggled, too, which meant that I wasn't the only one in this boat.
- P3: [About the course *Numbers and Operations*] WOW... it was eye opening. I only taught the fifth grade, so for me it was so great to see the foundation. They weren't teaching me "how to"; they were teaching me "why." In terms of learning the material [as a cohort], it was key that we felt so comfortable with each other. There was a good disequilibrium among all of us, and so I found real value in the cohort. We came together nicely.
- P1: Once I got into the class, it was all very different. It started with *Numbers and Operations*. It was not as bad as I thought. There were procedural [methods] involved, and also things like being able to decompose and recompose. As the program progressed, the most difficult class was *Probability and Statistics*. [To me], everything was pure procedure before that point. When I got to *Algebra* which was my strongest point, I was comfortable. [...] In each class, I think that my level of adaptation was based on how strong I was in that particular area.

In their own way, each of the three participants proceeded to elaborate on the extent to which the content courses challenged them. The common sentiment can be summarized simply using the word "unexpected," as all three of the participants seemed blindsided by the extent to

which they were challenged. Thus, having established that there was indeed a wide disconnect between expectations and reality, we finally turned our attention to the crux of the discussion: “How did this disconnect affect the ability to learn pedagogy, leadership skills, or the presented content itself?” More specifically, the participants were asked if learning so much new content hindered or helped the learning process with respect to learning the pedagogy and finding new ways to convey this material to students and colleagues. For Participant 1, the answer was mixed.

P1: At first, it was hindering. I became defensive. For me, being certified for K-5, I came in thinking about learning new ways to teach the concepts. [I asked myself] am I going to be able to effectively convey this to my students and colleagues? I didn't expect to struggle. [In terms of the math], I knew that there are tricks that work, but I never thought about why the tricks worked. In the *Rational Numbers* class, I remember learning different ways to solve a problem, but [they told us] you cannot use procedural [methods]. I could not think of another way. There were times where I shut down. There were also times when I embraced it, but not often. If I could take a class over, it would be that one.

[...] But looking back now, I think that learning the content on such a new level improved my ability to absorb the pedagogical procedures conveyed because in my head I was learning along with the student. [And as I reflected on my prior knowledge] I felt cheated with respect to how I was taught. But I used this as motivation to learn and move forward despite how difficult the material became. [Feeling cheated] was the first step necessary for me to be willing to abandon my old ways of thinking.

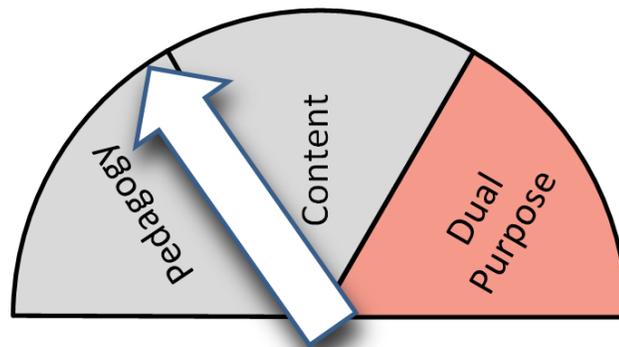
While her initial response was the quintessential Jane Doe Experience, her reflection at the end suggested that she was able to overcome not only these difficulties, but was able to ultimately use them to her advantage. Participant 2 didn't feel as lucky.

P2: For [the] *Rational Numbers* [course], I didn't get the satisfaction that I got from other classes. All of my most frustrating moments [happened in that class]. I didn't know what to ask [...] and so I participated less. I never got past learning for myself.

As it turns out, in my assessment of our conversation, it seemed that Participant 3 did not have a Jane Doe Experience at all. While she came across material that was unexpectedly challenging, it never seemed to affect her ability to move forward. We will further discuss the thoughts of Participant 3 on encountering new content as we close in the following section.

### The Focus Model

The interviews in the previous section were focused on determining the ratio of time that MSP participants spent focused on learning new content versus learning about methods of instruction as they pertain to the content. Two of the interviewees confirmed that this ratio being higher than anticipated negatively affected their overall learning experience at some point in time. To help explain this phenomenon, the participants and I came up with what I call the “Focus Meter” model of teacher learning (see Figure 1).



**Figure 1. The “Focus Meter” model of teacher learning.**

The diagram models the mindset of a teacher during the course of a program such as the MSP. The indicator arrow points toward the participant’s intended point of focus in a course, *as they see it*. While a participant can certainly experience both improved pedagogy *and* improved content knowledge simultaneously, it is reasonable to think that most participants will expect to focus their attention primarily on one of these two areas. Which area they choose may be based on their background and how the course is advertised. Accordingly, there are three sections in the Focus Model dial, each based on the type of expected learning outcome: improved pedagogy (S1), increased content knowledge (S2), or a dual purpose approach that allows the learner to serve both ends simultaneously (S3).

It seems that although some learners are restricted to the first two sections, it is still easy for them to switch from S1 to S2 as needed. For example, Participant 2 presented herself as more of a linear thinker. That is to say that she had to *fully* absorb and understand the content before

moving on to strategies to convey the material. Presumably, these are the participants that are most susceptible to the Jane Doe Experience. Participants 1 and 2 were alike in that both seemed unlikely to achieve S3 status. However, Participant 2 did seem able to move her indicator arrow back and forth between S1 and S2 within the same context. For teachers similar in mindset to Participant 1, this back and forth between S1 and S2 is achievable within a single lesson, but the participant's personality may dictate whether this is an effortless action or whether it takes a conscious effort to move the needle from one section to another. Either way, the good news is that it is possible, and not necessarily a painful process for the learner.

Section 3 of the Focus Model dial is the ideal situation in which the participant can recognize the need to absorb new content while simultaneously considering strategies to subsequently convey this deeper knowledge to other teachers and students. This section of the dial is not an area that is easily attained by all learners. Participant 3, however, seemed to reside quite comfortably in Section 3. During her interview, she discussed the value of a high "new content" to "pedagogy" ratio as it pertains to achieving the desired learning outcomes.

P3: I had a tendency to enter each class with an "I can do this" mentality. And even though that wasn't always the case, I don't think that learning new material ever really threw me for a loop. [Even in challenging situations, I remained] pretty comfortable switching from "learning for me" versus "learning for my students." What I realized is that when you learn for yourself, there's this overlap because you can learn for your students at the same time and figure out how *they* are learning.

For such learners, the end result is arguably richer. They are able to experience the potential pitfalls, typical questions, and "aha moments" for themselves—all while *in the midst* of considering how to convey the material to a third party. This approach can promote better retention of lessons learned and thus enhance their ability to coach. However, the inability to reside in Section 3 does not spell doom for the other types of learners. While the details of their experiences may have been different, we are reminded that all three of the interviewed participants essentially started and ended at the same place. The program began with each participant having little expectation of changing their content knowledge set; and, during the course of the program, the participants certainly differed in how they handled the obvious disconnect between their expectations and reality. However, in the end, experiencing first-hand the learning curve of new content knowledge clearly benefited *each of them* as they were able to embrace the pedagogical aspects of the lesson on a more personal level. For some, this embrace was simultaneous to learning for themselves. For others, it was subsequent. For all, however, the transformation of thought processes could be deemed a success as the ability to unlearn, re-learn,

and think more deeply about content knowledge and the corresponding pedagogy that was still achieved across the board.

From here the question that lies ahead is, “What can be done to better promote ‘Section 3’ experiences within teacher learning environments?” With five more years of our MSP program ahead of us, we will hopefully have plenty of opportunities to uncover and begin to implement the answers to such questions.