

**Studying Students:
The Effect of Case Development on Teaching**
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Several years ago I was asked to write a case to be discussed among elementary school teachers who were expected to teach science, but generally lacked deep content knowledge in the subject. Developing a written case about a science learning dilemma from my own fifth grade classroom resulted in much more than a well-researched document of practice. It served as a gateway for me to become a wholly different type of teacher as I learned to recognize and to critique important elements of my own practice.

In this paper, I will begin by sharing the intense and highly gratifying experience I had as a case writer for WestEd – a research and service organization in education headquartered in San Francisco. Second, I will relate this personally meaningful professional endeavor to the larger discourse about the benefits of teachers “going public.” And finally, I will summarize what I learned by interviewing other teacher case writers about the impact of this professional development experience and share evidence of how the experience of case writing was a catalyst for profound professional growth.

How it all began...

My involvement began at a friend’s house over Thanksgiving Dinner. Another guest at the table was Mayumi Shinohara, a researcher at WestEd. We found ourselves engrossed in a conversation about learning and classrooms, and we discussed the mixed success teachers, especially elementary teachers, have in promoting scientific literacy and inquiry in classrooms. At the time, I regarded myself as a model teacher of science. With Mayumi, I would soon embark on a journey that would redefine my notion of what constituted effective teaching. She carefully screened me in the coming weeks and finally proposed that I “write a case” for WestEd’s collection of dilemma-based, content cases intended to promote real science learning among elementary teachers through facilitated discussion. Not even knowing exactly what that meant, I agreed. She came to my fifth grade

classroom in San Francisco and gave me a thoughtful two-hour reorientation to the materials I had used comfortably for years (batteries, wires, bulbs, motors, magnets, etc.). Mayumi also examined my entire curriculum related to magnetism and electricity, and shared her thoughts about what misconceptions she had noted in her observations of students in other classrooms. We discussed what was hard about the science and what was hard about teaching the science and where there may exist a high probability of learning going awry.

Mayumi explained that in order to present my case publicly I would need to communicate my thinking, my students’ thinking, the science content involved, and the evidence of what I claimed to be true. These aims alone were enough for me to shift my mindset and think more about what the students were *learning* rather than what they were *doing*. I was given the task to be watchful for a “dilemma” that emerged while I taught the unit – in other words, to think about when my students were thrown intellectual curve balls in my science class. After noticing some serious confusion about compasses and what “north pole” meant in various contexts, I had my *Eureka!* moment and began drafting a narrative explaining what had happened in class. I attempted to capture not only the essence of my students’ thinking, but also began to explore, in a new way, what specifically contributed to student misunderstanding.

Soon after my initial meeting with Mayumi, I met my cohort of case writers. We were accomplished elementary teachers from all over the Bay Area, who were undertaking the same writing and research task with different, but related, science content. Kirsten Daehler and Mayumi Shinohara of WestEd facilitated a collaborative revision and editing process that was rigorous and focused on the goal of creating a quality product for teacher learning. While Kirsten and Mayumi served as science content experts, and ensured that the cases were embedded with rich and accurate science, they

also promoted profound professional growth among those of us who were tapped to write cases. This is in part due to their maintaining a dynamic among the group members that invited a sense of mission, shared purpose, thoughtful exchange of ideas, and communication that evoked questioning/inquiry.

Case-writing: Good case for Going Public?

Part of my positive experience as a case writer was due to the well-crafted process of developing cases as described above. Yet another larger, more encompassing concept is at play here – going public as an educator. Thomas Hatch and Ann Lieberman’s leadership in the discourse about what it means to “go public” relates to case writing in important ways. Going public is much broader than the issue of developing a case as a classroom teacher. Hatch and Lieberman advocate publication in many forms, including web-based media, as a way for teachers to become less limited by the confines of a classroom. Hatch reminds us that “it would be unthinkable to imagine doctors or scientists who had such limited access to the work or discoveries of their colleagues” (in press). Lieberman now directs the Carnegie Academy for the Scholarship of Teaching and Learning (CASTL) for K-12 teachers and teacher educators at The Carnegie Foundation for the Advancement of Teaching. This focus on the scholarship, or “means for teachers to develop and share their expertise with others” (Hatch et al, 2001) includes the convening of teachers with a record of inquiry-based professional endeavors to document and publicize a key question or concern related to their practice.

Currently, there is exciting movement in this field. In addition to Carnegie’s CASTL program, elements of the National Board for Professional Teaching Standards certification process include documentation of practice in a form that communicates to colleagues concretely and unambiguously about the perceived effects of one’s practice. The expansion of Lesson Study programs in the U.S., such as those led by Catherine Lewis at Mills College in Oakland, Clea Fernandez at Columbia University, and Liping Ma at the Carnegie Foundation, also fold into their design the professional task of communicating practice in a way that addresses fundamental problems. The continuation of action research programs both for preservice and inservice teachers is another strong example.

Lee Shulman also argues that there are many forms of knowledge that are gateways to reflective teaching. One of which, pedagogical content knowledge, relates very closely to the use of case methods. Shulman explains pedagogical content knowledge in two basic ways: 1) “A mature enough understanding of the content and the ways to present the content to students.” 2) “...the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that makes it comprehensible to students” (1986). Another element of pedagogical content knowledge focuses on developing an awareness of student thinking. Shulman explains: “Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons” (1986). Of course many conceptions and preconceptions children bring to the classroom are indeed misconceptions.

Common misconceptions are often the focus of cases developed by WestEd for teacher education and professional development. What seems to be an overarching aim of nearly all programs or publications using case methods, is to develop case knowledge. Shulman describes case knowledge as “knowledge of specific, well-documented and richly described events” (1986).

Case development, in collaboration with other teachers and with science content experts, certainly fits nicely into the realm of going public and further developing a stance of inquiry among teachers (Ball & Cohen, 2000). This paper was inspired by a professional epiphany brought on by the rigorous task of case writing and the added weight of producing a document for publication. Given the notable growth in my own pedagogical content knowledge and profound change in my teaching practice that resulted from case writing, I wondered about the experience of other case writers. This question of impact led to an interesting piece of research. Much of the rest of this paper describes, very specifically, what profound changes other teachers were the benefit of their involvement in case writing at WestEd.

Method

Data were gathered primarily through interviews with five educators who had significant exposure to case writing, case discussions, and a perspective on how case writers’ efforts to develop a case may impact their own practice. With one exception, I conducted the interviews. Three of those interviewed were teachers who developed cases for the WestEd Science Case Methods for Teacher Learning Project. One interview was of WestEd’s independent evaluator, Joan Heller. In addition, Joan Heller interviewed me. She has significant experience and perspective in the area of teacher education and professional development. The questions she used to interview me were intended to serve as a measure of the content knowledge and pedagogical content knowledge gained by other participating teachers.

The participants:

	Current position	Years of Experience
Naomi Reagan*	Elementary science specialist	15
Gary Carter*	Grades 4 & 5	10
Gina Harris*	Grade 2	13
Matt Ellinger	Grade 5	15
Joan Heller	Researcher	

*pseudonym

Analysis

Upon completion of extensive interviews, I examined the transcripts to identify common themes in issues raised that pertained to teaching practices. Each participant's interview was distilled to 10-20 "kernels" that were representative of a participant’s responses in general terms. I used cross-case analysis to compare participants’ statements in the realms of pedagogical knowledge, content knowledge, and pedagogical content knowledge. Five issues emerged as most prevalent – each raised by four or five of those interviewed. I intend to elaborate upon and contextualize these common effects by presenting direct accounts of what teachers said about their practice and what Dr. Heller shared about her observations of teachers associated with case writing.

Findings

The following five issues emerged, as aspects of the teaching profession, that appear to be developed by the process of writing a case about a learning or teaching dilemma. Of course one’s teaching practice can be developed in a variety of ways, but the participants interviewed linked case writing to their professional growth in these ways:

1. LISTENING WITH PURPOSE

A new deeper level of listening to students was developed through the experience of case writing. Perhaps at first for practical reasons in order to collect better data, but later this shift permeated practice. This more highly-developed form of listening served to inform teachers of how to modify practice, to gain understanding of student perspectives more effectively, to shift teachers to a more learner-sensitive approach, of electing to interrupt students on fewer occasions, and to allow students to arrive at an understanding rather than coaxing them toward the “right answer.” Teachers redesigned learning activities so they were better able to hear from more students. Class discussion and content-related discourse was elevated in teachers’ minds as “real work” alongside labs and pencil and paper activities.

2. INCREASED DESIRE TO UNDERSTAND STUDENT MISUNDERSTANDINGS

A new understanding of the importance of deeper analysis of student misunderstandings was developed and in time pedagogical reasoning was improved. This included making more informed decisions to modify instruction, refocusing lessons to address common misunderstandings, engaging more thoroughly with students and with the content, providing more equitable instruction, increased teacher understanding of how concepts relate, and more critical approaches to determining whether or not students understood.

3. ONGOING REFLECTION ON TEACHER DECISIONS

As a result of case development, teachers became more critical of their own practice, content frameworks, and curriculum. More effort was devoted to sorting out numerous variables contributing to learning or misunderstanding. These variables include language, materials, pedagogy, lack of conceptual context, and classroom management issues. Teachers stated that they learned from the experience and focus of content in their cases and in the cases of their

writing cohort and predicted that it would improve their practice. The responsibility of conducting this research helped the teacher to focus upon student work and learning. Since they were to report their findings to their colleagues, this added another layer of importance to their work.

4. COLLABORATION WITH COLLEAGUES FOSTERED

Collaboration took on many forms in the case development process. Participants had access to experts in the science content areas, and these experts observed instruction and offered guidance in research, curriculum implementation, and assessment. Teachers also worked together to identify dilemmas and develop a narrative account. In this phase, teachers reported that the detail-oriented discussions regarding their practice were highly beneficial. Also, the varied background and topics of their writing cohort helped to raise their general content knowledge in science and allowed for profound insight into decisions made by other experienced teachers. Most significantly, this practice of teachers learning from one another promoted on-site collaboration independent of the project and caused some to question how better to utilize “team-time” at their schools.

5. DESIGNING ASSESSMENTS THAT PROVIDE REAL DATA

Like listening, teachers’ new focus on assessments was at first aimed at getting real data regarding student knowledge for writing the case. Later teachers adopted the practice of more thorough and thoughtful assessment throughout their practice, as the benefits of such assessments became more apparent. Teachers modified assessments to correspond with prior instruction and determine follow-up activities. Instead of simply testing for facts, responses were intended to be accurate and helpful indicators of concept knowledge. Assessment became more open-ended and a range of responses was desired, instead of avoided. Teachers became more comfortable using pre- and post-assessment models, and they established sensible benchmarks to gauge progress. With the knowledge that their assessments were intended to communicate to a larger community, teachers worked to be clear and to create thorough accounts of student thinking via assessment. Each of the five issues described above is an element of the effect of case writing on teaching.

In the analysis that follows, I will detail how the various participants in the study commented on how case writing specifically affected their practice. While the responses vary, compelling themes emerge, all of which can be linked to the task of writing a case.

The structure of the remainder of the paper is as follows: each of the five issues is defined and contextualized, and then the specific effects listed. Following the effects are quotations intended to support the claimed effects and to connect them to the teaching practice of each participant.

#1 - LISTENING WITH PURPOSE

Study participants all raised the issue of listening to students “in a new way.” They spoke of the necessity of careful listening in order to collect data for developing a case. This supported a renewed regard for the value of listening to what the students were saying in class. In the following interview excerpts, the educators participating in this study made a number of points about listening to students. These effects include:

- a. Listening informs teachers about how to modify practice
- b. Listening helps teachers gain a better understanding of student perspective
- c. Interrupting students can be counterproductive
- d. Discussion versus coaxing toward a right answer
- e. Lessons structured to enhance listening to students
- f. Discourse among students deemed as valuable “work”

a. Listening informs teachers about how to modify practice

During Dr. Heller’s interview of me, she asked whether I found myself listening to students in order to make decisions regarding how to teach. I responded:

I think that’s probably the most valuable thing...hearing the kids’ confusions and then going back as a teacher and correcting the directions and correcting the way you ask questions. So it nudges them more toward the content, rather than the way we always just talk (often incorrectly) about everyday things like flashlights and switches.

b. Listening helps teachers gain a better understanding of student perspective

Ms. Reagan was asked how case writing may have affected her teaching and she sees how she has gained skills in understanding her students' perspectives. She identifies listening as a primary way to gain that perspective.

I hope that I am quicker to listen to what they have to say. That I am better, I mean I am always trying to get inside of their heads and see it from their sides. That I am more skilled. You'd have to ask them, and I don't know how you would measure it. My own sense is that I'm making a bigger effort to listen now.

c. Interrupting students can be counterproductive

Ms. Reagan goes on to say that part of listening is not interrupting. Aside from the obvious esteem issues related to listening without interruption, she feels that without a thorough understanding of what the students are saying and thinking, teachers are less able to meet their needs. Again, she listens fully to the misunderstanding in order to inform her instructional decisions:

I am making a much bigger effort to listen to what they say and try to not interrupt what they say to get to their misunderstanding. So that I can more effectively deal with that misunderstanding and correct it. So I think I am becoming more skilled at doing that. I am definitely putting more effort in to it. I am looking more carefully at, and thinking more carefully at the kinds of answers that I see in the labs. When they are incorrect I attempt to figure out what the kid was thinking to come up with that wrong answer, so that will inform my instruction. Not only in restructuring the instructions and the questions, but also in the introductory comments. Or I actually revise the structure of the lab itself, the order in which we are doing things, or how to manipulate the materials or the experiment.

d. Discussion versus coaxing toward a right answer

Ms. Harris credited a fundamental shift in her own concept of listening as a teacher to her case

writing. Previously, as she led discussion she "fished" for correct responses disregarding wrong responses or guesses.

The main thing that [case writing] affected me on was I always thought I listened to kids and what they said, but I realized what I used to do is listen for what I expected them to say.

She now values discussions as a process of building knowledge.

e. Lessons structured to enhance listening to students

Motivated at first by her need to collect data from individual students, Ms. Harris designed lessons so that she was able to confer with individual students. She then learned that some students were more apt to engage in a meaningful dialogue when the teacher is not simultaneously managing the entire class and listening to individual students. Pleased with the connections she made with students after meeting with them individually, she has incorporated one-on-one instruction to other areas of instruction:

I also found that when I was in the one-on-one I could listen better and respond better to their comments. We had more of a dialogue. In the whole group I realized that I am juggling more of the behavior issues ... and I realized that that makes it hard to respond meaningfully to dialogue.

f. Discourse among students deemed as valuable "work"

Mr. Carter found that his approach to developing a case relied entirely on listening. While he always promoted dialogue among students, case writing reinforced his contention that student "work" need not always be on paper or with a particular apparatus. In Mr. Carter's cases, he embedded numerous student quotations. These quotations are his vehicle to communicate to his colleagues the teaching and learning dilemmas intended to be addressed in the case.

The way I write the cases and think about it is that I hear the kids talk. So there's a lot of dialogue that I create. I either create it or remember. The student work for me is like key points to remember what was said in class and what was done. They are really like "Post-its" or reminder notes of what happened.

#2 INCREASED DESIRE TO UNDERSTAND STUDENT MISUNDERSTANDINGS

Teachers who authored cases also spoke of the importance of deeper analysis of students' misunderstandings in order to inform instruction. More specifically, they were able to link specific student difficulties with instructional methods, to cite examples of how conceptual difficulties were manifested in student work, and to access a greater fund of knowledge regarding what makes learning difficult in terms of science and student cognition.

In the excerpts that follow, teachers describe how student thinking is explored thoroughly as data for case writing. But as they explain, this increased attention had a positive spillover effect on their teaching practice in the following ways:

- a. More informed decisions when modifying instruction
- b. Refocus lessons to address common misunderstandings
- c. More thorough engagement with students
- d. More equitable instruction provided
- e. Increased teacher understanding of how concepts relate
- f. Teachers developed stance as a critical consumer of student understanding

a. Decisions to modify instruction

This improved pedagogical reasoning in turn was shown to lead to more informed decision-making by teachers. For example, Ms. Reagan decided that her use of a metaphor for teaching about resistance in an electric circuit needed to be modified based on her analysis of student thinking. The sensible idea of comparing resistance to a bicycle brake was lacking when she considered carefully how her students were applying the metaphor to the concept:

...with resistance I even gave them a model of how you use your brakes on your bicycle to stop yourself or to just slow yourself down. And the kids tended to see it as a nothing or an all. Either you have resistance and things don't go anywhere or you don't have any resistance and electricity flows. And they missed that whole in-between gradation of a little more and more and more. So having seen those misunderstandings I have more visuals

... I draw a graph, and I make a real big point of talking about three or four levels of applications of brakes. So the kids see that it is a gradation rather than an all or nothing. So now when I hear of a misunderstanding I highlight it, and I then go back to my instructions and I revise it to try to eliminate or to address those misunderstandings.

b. Refocusing lessons to address common misunderstandings

During Joan Heller's interview of me, I related what I thought was a fundamental problem when teaching electric circuits using batteries, and how the way we phrase our questions can actually compound problems. The science concept with which I was working was: Which kind of electric circuit uses more electricity – simple, parallel, or series? One way to test for this is to make the various circuits to see which “lasts the longest.” What I failed to understand is that activity is based on a basic understanding of a battery as the electricity provider:

... I never thought of this kind of thing - about how to teach the battery. I never thought about it until I discussed this case last week –the whole idea of kids thinking the bulbs burn out. I'm sure I said it too. Which bulb is going to go out first? And you really do mean that, go out first, but they're all thinking burn out. They think it's all about the bulb. They are bulb-centric! And we are just ignoring the battery. Which we do in general, because the batteries are hard to teach. So you don't even talk about them. And this is a lesson about the battery, really. About which circuit is going to wear out the battery first.

That's what we should be asking the kids, not which bulb is going to go out first. So if you think about these things, and if you phrase them right... Maybe we shouldn't even be talking about the bulb. The bulb is an indicator of how the battery is doing. Indicator.

c. Engaging more thoroughly with students

Ms. Harris spoke at length about the importance of exploring student misunderstandings with her second graders. She, in part through her review of data collected on audiotape, became more proactive and engaged with students who were less vocal in the initial activities. She also found

that her students responded to her attention to their drawings by creating more detailed drawings in lessons that followed. She also spoke of talking through misperceptions in order to gain true understanding:

I realized from case writing how important it is to see if they really see, if they understand the concept and what they understand. The way that was so good was the verbalizing on the tape and going back through that. But I also learned how to better analyze their pictures. Then the more that I asked them questions about the pictures that they drew, the better the diagrams would become the next time. They would not do just a quick sketch but they would put in all kinds of details like in my case there was an experiment with cars. They put in every little detail even on the car wheels which had really had nothing to do with it, but they just included every detail they could think of which showed much more of what they were thinking about.

d. More equitable instruction provided

Ms. Harris also found that in her efforts to collect data on her entire class (not just the highly vocal students) that she was reaching out to students she felt might have been less inclined to participate otherwise. She goes on to describe how she moved past the practice of “starting over” when learning goals were not achieved:

My main motive was to find out what they didn't understand and a lot of those students tended not to talk and so I had to give a springboard to start them talking. And I think that my motive was mainly to get them to talk so that I could write down their misconceptions, but it actually gave them a framework to start talking and work through their misconceptions. They probably wouldn't have started talking, they would have just listened and maybe figured it out on their own or maybe not figured it out until later on.

[Exploring misunderstandings] is valuable. That was not something that I thought before I wrote cases. I never really saw the value of exploring their misconceptions. I always sort of scraped their misconceptions aside and would start over. Like, “Oh well, they

didn't get that so let's do that from the beginning.” As opposed to taking what they understood and working with that. I really didn't do that before I started writing cases.

e. Increased teacher understanding of how concepts relate

Mr. Carter felt that his students' concept knowledge has been more closely scrutinized because of his case-writing experience and he has come to understand that relationships between and among science concepts are important in the scaffolding of introduced concepts. He is no longer *laissez-faire* in regard to sequence of particular science concepts in a unit of study:

I think that they have been examined more closely and remedied if they had certain missed concepts. So if they didn't know what a series circuit was, before I would have just moved on thinking well, they will get it when we do parallel or something like that. Or I would have focused on some concrete aspect of it, like that they didn't know how to build a series circuit versus that they didn't know how it worked or they couldn't explain something. Now, after writing these cases I would be much more attuned to the fact that it's really important that they get this before they get that, so to speak. And they need to be able to explain it to me on some level. So yes, the assessment and the remedying and the revisiting of items or revisiting concepts in a different way... that has definitely come out of my case writing.

f. Teachers developed stance as a critical consumer of student understanding

Dr. Heller explained that a teacher's analysis of student misunderstanding leads to a more appropriate teacher stance when observing and questioning students. This stance helps teachers to develop an approach that not only deals with what to tell students, but also *how* to tell them, taking into account their current knowledge. She believes that a teacher's role is, in part, establishing an ongoing practice that informs teachers in a real way what students know and do not yet know:

Being in combination curious and open without judgment but a critical consumer of your own students'

performance by saying ... you're not going to be necessarily jumping to conclusions about what they know ... you are going to be testing all the time. To see what is actually going on. So it's that critical analysis of practice piece. It's not only having a more sophisticated and complex understanding of a content area and understanding of students' understandings and misunderstandings in the content area, but it's also having a whole way of thinking about how to tell them what they need to know.

#3 ONGOING REFLECTION ON TEACHER DECISIONS

Teaching is complex work and rich with nuance. Three case writers pointed out that in the process of developing their cases; they found it necessary to reflect often on the goings-on in the classroom. By a thorough pulling-apart of many detailed questions regarding science instruction, they developed analytical skills regarding their own practice as a teacher. This was gained by:

- a. Sorting out numerous variables that can contribute to learning or misunderstanding
- b. Identifying specific elements of teaching
- c. Using prior experience to improve future practice
- d. Focusing the teacher
- e. Adding a layer of metacognition

a. Sorting out variables that contribute to misunderstanding

In my conversation with Dr. Heller, we discussed an experience in my teaching in which I felt that the choice of one particular verb in describing electric flow was at the root of a student's confusion. I relate an experience at a meeting of case writers:

So it gives you this unusual group of colleagues that actually wants to discuss the word "through" versus the word "light" and know that it's important. You could spend twenty minutes on that particular little topic, and everyone's intrigued by it. And debating it. And that for me is a whole new way of thinking about science. Talk about battery duration; talk about series versus parallel. You could talk

about the fact that in parallel you have a number of possible pathways, possible circuits, and that they are all okay. And then also the fact that batteries—you need to teach, I guess, directly or in some way get across that the battery isn't a constant. A battery has various levels of electricity that it can kick out. Like a faucet, you can turn it on pretty hard and you can turn it on not so hard. A battery has that ability.

b. Identifying specific elements of teaching

Ms. Reagan added a layer of analysis when thinking of how she plans to modify lessons to promote deeper understanding allowing her to frame her thinking in the following way:

And again I would say that the casework has made me more sensitive to these things. And allowing me to dig deeper, ask more questions of myself, and you're talking about the category of things ... I can ask myself now is this vocabulary? Is it instructional? Is it a materials issue? Of all those things, where is it that I need to change?

c. Using prior experience to improve future practice

Ms. Harris is eager to begin examining curriculum more thoroughly and with added perspective prior to instruction to predict what may be more challenging for her students to learn or where she herself may need support:

I probably tend to do that more thinking back over a discussion as opposed to projecting ahead what might be challenging. I'd like to do that more – projecting ahead – but I'm probably at a stage where I'm thinking back over the day myself. So that maybe how I plan for next year is thinking back.

Along the same vein, Mr. Carter admits that when describing his own teaching in the cases, his account is semi-fictionalized in order to present the more rigorous student thinking that he is now prepared to facilitate since developing a case:

And to be honest, it's interesting. I think a part of this writing is kind of a "I wish I had been that way" situation. So when I go back to teach it again... like right now I'm teaching electricity and magnetism to third graders, the same unit, and I've done things differently

because I am doing things the way I said I did them in the case.

d. Focusing the teacher

Ms. Harris found the need to uncover a learning dilemma among her students to be a motivating factor in improving classroom management techniques. In order for her to achieve a heightened awareness required by the case writing, her management needed to be strong:

I think that when you write a case you have this other layer, having a dilemma and ... I think that since you have another layer of things you are thinking about them in order to do that that's one more ball that's in the air and so you really have to make sure that your management of behavior is really on top of it.

e. Adding a layer of metacognition

Dr. Heller described case writers as developing an ability to think about their teaching on a number of somewhat unconventional levels. This is due to the fact that they have the task of describing classroom events in ways that will be meaningful to the larger educational community:

You have a metacognition, another layer of metacognition, you're not only thinking about your teaching and thinking about how you think about your teaching, you are thinking about people's thinking of their teaching. And so you'd have to be more aware of the possibilities and the condition under which they would then develop certain ways of thinking. Therefore carrying back to the students about what is going to be good practice in the classroom.

#4 COLLABORATION WITH COLLEAGUES

The issue of collaboration among teachers emerged as a prominent theme in the discussions with the study participants. The case development process that each participant experienced was highly collaborative. Each case writer was assigned a manager who had in-depth science content knowledge and experience with case development and other qualitative research methodologies. Teachers met together as well to discuss not only the science content to be explored in classrooms, but also the pedagogical choices and challenges that accompany teaching science. Those interviewed all said that this

collaboration was beneficial professionally and had a positive effect on their teaching practice.

Specifically, they mentioned the following regarding collaboration:

- a. Details became more important
- b. Varied backgrounds helpful
- c. Learned of other teachers' approaches
- d. Promoted on-site collaboration
- e. Association with experts
- f. Science content knowledge jumped

a. Details became more important

I found it very helpful to have a group of teachers with which to really grapple with learning issues. I described to Dr. Heller getting to discuss a word choice in my teaching with colleagues made it something I pursued with deeper thought :

The case discussions have brought—well, it's created a group of teachers—I think what's most powerful about it to me is that instead of just thinking to myself, "Oh, I should say 'through' instead of 'light,' when teaching the bulb...". It sort of made it all-important, suddenly – getting to talk about why I thought it was important.

Ms. Harris credits her colleagues in case writing for helping her to learn how to examine work with a core critical eye:

And as far as student work, one thing I did learn in writing a case is I realized I didn't look as carefully at every detail of student work at the beginning of my case writing experience, and it wasn't until I sat down with the small group of writers, the four people, and heard what other people saw about the student work. Because I was thinking that this work didn't give me any dilemmas. I don't see anything that's interesting as far as misconceptions go until they started pointing out little details about it.

b. Varied backgrounds helpful

I found it to be profoundly helpful to be part of a community of colleagues some of whom have a deeper understanding of particular science concepts and yet others who have taught the same material in previous years:

I can read the teacher manuals and figure out how to do the lessons pretty

well. But my learning style's much more compatible with a discussion group, where people are just talking about electricity and the questions sort of go in one direction and there happens to be a person who has a background in physics there, so that all the teachers actually get to share what it felt like not to know and how much better it feels now. You hear folks say, "Yes! They always ask that, and I never quite feel like I give them an answer!"

c. Learned of other teachers' approaches

Ms. Reagan appreciates the exposure to other teachers' approaches in developing a case and in teaching science:

It's definitely been a rich experience. Partly, just from the editing process. And just watching people go through the steps. But discussing everybody's cases it just keeps adding pieces to my repertoire, my awareness of things.

As does Ms. Harris:

One thing that I learned more from our case writing discussions is how other teachers think about their teaching. I had only ever known how I think and how I set out to plan a lesson or how I think through what I am going to teach.

Mr. Carter said that his case writing colleagues were a particularly helpful resource to him when faced with teaching unfamiliar material:

I ask other teachers. And the case writing teachers... you can ask them. Being in all those cases year after year. They know what was hard and what wasn't.

d. Promoted on-site collaboration

Ms. Harris longed to bring similar collaboration to her own school. She bemoans the fact that her time with her team seems underutilized:

I would say that sitting down with colleagues, that whole piece of it, is something that I never really do on any deep level apart from case writing. When the second grade team sits down it is always about details of strategic things, it's not really about children's learning so much. And I really see the value of that, sitting down and making the time to talk with other people about that.

e. Association with experts

When asked how the collaboration required in developing a case has impacted his thinking about his teaching practice, Mr. Carter responded:

Profoundly! Mayumi (WestEd's Science Case Manager) was in my classroom and helped me teach the unit and then helped me conceive what the student work could tell me. That was really a powerful thing because I could talk to someone who was educationally superior to me, in this area. But we were talking as equals, because she didn't really know what it was like to work with little kids on these topics. So it was a negotiation, and Kirsten (also a WestEd Science Case Manager) has been the same, because all the time I've had to justify what I think and they ask all the time, but they don't put me down or anything. They ask and they keep on delving in, so it's like justification. This is what I think is going on because of this... it's really profound, really profound.

f. Science content knowledge jumped

This association with experts and with other case writers contributed to a much more thorough understanding of the science content. I explained to Dr. Heller:

My knowledge level jumped after being able to do the case discussions. Before I started doing them, basically it was attending mediocre science workshops for teachers from time to time, and I don't think I would have been able to really get it, all this stuff, until it was pulled apart. When I was developing a case last year, one of the other writers did resistance and I didn't even know what resistance was until last year. So I learned a whole lot from doing a case with her. It raised my own intellectual standards as a teacher.

#5 DESIGNING ASSESSMENTS THAT PROVIDE REAL DATA

Much of the data used in this project's process of developing a case was gathered through student assessment. With this secondary reason to document and to understand fully what students do and do not understand in class, teachers

designed assessments that provided them with richer information. This more thoughtful design affected their teaching practice in that assessment became a greater factor in decisions made by the teacher during the unit of study related to the case and in following units of study. All the teachers interviewed attributed changes in assessment to the case development process. Specific changes included:

- a. Assessment designed with before-during-after in mind
- b. Responses intended to be accurate and helpful indicators of knowledge
- c. A range of responses was desired, not avoided
- d. Pre/post-assessment utilized, benchmarks established
- e. Assessment was designed to communicate to other professionals
- f. Assessment was found to be validating of the student's experience

a. Assessment designed with before-during-after in mind

When presented with the specific challenge of assessing student understanding as to why a particular bulb would light in a circuit, I described during Dr. Heller's interview how to assess their understanding rather than their task mastery. This approach to assessment, which I learned through data collection for case development, includes an accounting of what would be good for students to know before upcoming lessons:

I would want them to know if bulb number one will still work even when you unscrew bulb number two. I'd want them to be able to identify that there is a complete circuit independent of bulb number two. And I'd actually like them to go on to say, be able to predict, that if you unscrew bulb number one, and screw number two back in, that it would light. And have them come up with the reason that it's a complete circuit, independent of bulb number one. They could then start understanding that parallel circuits are collections of simple circuits.

b. Responses intended to be accurate and helpful indicators of knowledge

The assessment described above not only determines whether learning objectives are achieved, they also inform the teacher of next

steps to take. There should be a game plan for those who understand and remediation planned for those who do not. When asked about a student who did not demonstrate understanding, I shared a remediation approach and raised a shortcoming of a previous assessment.

And I would go back and test it with him, and probably what you need to do is to make a couple of circuits—to make two models of this exactly, side by side, with new batteries, or with batteries that are about the same, and then have all four bulbs lit. And then you'd unscrew the number two bulb and then you'd compare number one to these over here, because my assumption is that it's harder for a child to make a comparison with something that's off, you know, than it is to...

c. Assessments designed to get a range of responses

Ms. Reagan pointed out that assessments she created for case development were more open-ended. Equipped with more telling data, she was quite surprised not only by how some students were struggling, but also how some students understood in much more sophisticated ways than the teacher anticipated:

Well I think any time I do these extra assessments with the cases, I think I get more from the kids. I get some really surprising stuff. One of the assessment questions for this year's case, motors and electromagnets, was about how the motors worked. When I taught the motors piece I stressed to the kids the repelling of the magnets, just because the timing for attraction is so much trickier, you can get it wrong and your magnets attract and you have no more movement. A few got it, but two really nailed it. I mean, they may have done it on their own, without the prompt of the assessment. I had no clue, but the assessment showed so much. I definitely would not have been aware of these strengths.

d. Pre/post benchmarks established - assessment designed to communicate globally

& e. Assessment was designed to communicate to other professionals

Mr. Carter feels that case writing introduced him to a new way of thinking about assessment. He

now sees assessment as a tool to communicate to others regarding what is happening with his students, to determine next steps in instruction, and to gauge what learning has occurred as a result of current instruction.

What I really got out of this whole process that revolutionized who I was as a teacher is it made me think about assessment. Because it's been a vague term we use on a professional level. "We have to assess, we have to assess..." But in cases because you're motivated to present something that you understand about your class, so you have to really delve into what the kids are thinking and saying and try to interpret it. Before I go into a unit, I think about what are some areas that can be problem areas. Then I look for some benchmark activities that are going to give me a sense of what they have understood. I think a lot about what are the pre-assessments and post-assessments that I may be using down the line.

f. Assessment can be motivating

Ms. Harris shares that prior to her work with case studies, she spent no time assessing her second graders in science. She found that not only was her new attention to assessment helpful to her as she planned instruction, but she also found that her increased attention devoted to drawings and written responses was motivating to her students. They appreciated the opportunity to share their thinking and would add detail to their work so that they would have more to explain:

So I actually didn't spend any time assessing before. But I realized from case writing how important it is to really see if they understand the concept and find out what they don't understand. The way that was so helpful was recording the students' thoughts on tape and going back through that. I also learned how to better analyze their pictures. Then the more that I asked them questions about the pictures that they drew, the better the diagrams would become the next time.

In Conclusion...

Again, the five most prominent issues of teaching practice affected by the case-writing process were:

- 1. LISTENING WITH PURPOSE**
- 2. DESIRE TO UNDERSTAND STUDENT MISUNDERSTANDINGS**
- 3. ONGOING REFLECTION ABOUT TEACHER DECISIONS**
- 4. COLLABORATION WITH COLLEAGUES FOSTERED**
- 5. DESIGNING ASSESSMENTS THAT PROVIDES REAL DATA**

Ball and Cohen discuss two important related concepts. First is the concept of productive disequilibrium (1999) as "terrain for new learning." They advocate the use of authentic artifacts of the teaching practice as is required in the case development process described in this paper. Also Ball and Cohen tell about the importance of the development of a disposition of inquiry among teachers (1999). Certainly those who read and discuss cases for professional development are nudged toward a stance of inquiry due to the design of the cases and their supporting facilitator materials. The case writer, however, who here is also a classroom teacher by profession, also enjoys such an effect, but in a highly concentrated way. This is due to the nature of the work, the transformations necessary to do the work well, and the power of going public.

Having teachers engage in thoughtful, collaborative, qualitative research with the guidance of content experts is obviously a good thing. It is safe to say that pedagogical knowledge, content knowledge, and pedagogical content knowledge were all increased among teachers interviewed. An example is the discovery of my own lack of understanding, throughout many years of teaching circuits, of what a battery actually does. Case writing prompted me to develop a thoughtful and accurate approach to simulate how a battery provides the flow of electrons for a circuit and how resistors slow the flow and cause the battery to "work less" not more. Prior to writing cases I would not have included in my instruction with elementary students the idea that the flow of electrons from a battery would differ depending on the make-up of the circuit. I also thought in new ways about how I could convey to children that a bulb in a circuit is not the destination of the flow, but more like a town you travel through during a journey. This type of knowledge and its newly understood relevance to the "big picture"

of electricity is evidence of my gain in pedagogical content knowledge.

But how might this endeavor, producing a case for other teachers about a learning or teaching dilemma, sit with a larger theory of professional learning for teachers? I contend that this form of documentation of practice with the association of content experts is a thorough, professionally challenging, and compelling form of professional development, but is also a form of scholarship. The product (here the science cases) inspires case discussants to engage with colleagues to unearth dilemmas inherent to teaching science to elementary school students, but the process of developing the cases raises especially powerful, even alarming, questions for the case writer as he or she puts together a case. Questions that, when explored, result in profound professional growth.

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