

Science Teachers' Pedagogical Discontentment: Its Sources and Potential for Change

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Abstract This research explored science teachers' pedagogical discontentment and described its role in teachers' consideration of new teaching practices. Pedagogical discontentment is an expression of the degree to which one is discontented because one's teaching practices do not achieve one's teaching goals. Through a series of structured interviews conducted with 18 practicing science teachers of various grade levels, content areas, routes of preparation, and amount of experience, areas of commonality in the teachers' pedagogical discontentment were identified. The common areas of pedagogical discontentment include the ability to teach all students science, science content knowledge, balancing depth versus breath of instruction, implementing inquiry instruction, and assessing science learning. We draw implications for using this construct to craft more effective professional development.

Keywords Teacher self-efficacy · Pedagogical discontentment · Contextual dissatisfaction · Teacher beliefs · Conceptual change · Affective factors

Introduction

In an effort to change the way teachers conceptualized their work, reform efforts in science push for teachers to focus their teaching on a small number of the major

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science concepts in order for students to develop deep conceptual knowledge. It is argued that reform-minded science instruction will not only increase students' conceptual understandings but also allows students to become more capable of using this knowledge to inform personal and societal decisions (American Association for the Advancement of Science 1990, 1993; Duschl et al. 2007; National Research Council 1996). Simply put, the reformers argue that when students are supported in learning to inquire into science, they can understand, discuss, and apply knowledge learned in this fashion much more productively. Unfortunately, practices associated with reform-minded instruction of science (e.g., inductive approach to material, inquiry, argumentation, application of knowledge) are fundamentally different from traditional classroom practices (Crawford 2007; Huffman 2006).

The current call for the reform of science teaching seeks to change the very way teachers and students interact with their content. However, in their review of reform efforts in education, Woodbury and Gess-Newsome (2002) introduced the phrase "change without difference" to describe the influence of these reforms on classroom teaching. These authors argue that there has been a huge effort placed in precipitating educational change, but with little resulting difference in classroom practices. What accounts for this "change without difference?" Woodbury and Gess-Newsome (2002) answered that it is due to the scant attention past reformers have given to teacher thinking. This has changed in recent years and currently the importance of addressing individual teachers' thinking is viewed as a cornerstone of the success of any reform effort (Bianchini and Cavazos 2007; Crawford 2007; Johnson 2007; Kang 2007).

Woodbury and Gess-Newsome (2002) suggest that a teacher's abilities and/or inclinations to learn and relearn conceptions of content, learning, and teaching present the most profound influences shaping the change of teaching practice. There is an extensive literature that focuses on the various factors that influence teachers' learning (Bianchini and Cavazos 2007; Crawford 2007; Gess-Newsome et al. 2003). The findings of this literature suggest that teacher beliefs, while remarkably durable, can be changed, although the change process is often difficult to instigate and requires support. Anderson (2007) posited, "much of the difficulty [in enacting reform] is internal to the teacher, including teachers' beliefs and values related to students, teaching, and the purposes of education" (p. 7).

In attempting to understand teacher learning, Hewson (1992) argued that like science learners, teachers hold conceptions of what it means to teach science, and these conceptions may be fundamentally different from those described in reform efforts. So, just as students undergo conceptual change in their learning of science, teachers can be understood to undergo conceptual change in their learning about science teaching. In following through with this argument, teacher learning depends on prior knowledge interacting with teacher beliefs and affective consideration as teachers engage in new experiences related to teaching. Indeed, many have argued that teachers' learning about science teaching can be understood as a conceptual change involving their conceptions of the nature of knowledge, of science, and of learning. They further argue that such conceptual change a process that is heavily influenced by a host of beliefs and other, more affective, factors (Southerland et al.

2010; Dana et al. 1998; Gess-Newsome et al. 2003; Gregoire 2003; Sunal et al. 2001).

Each of the current models of conceptual change (Dole and Sinatra 1998; Feldman 2000; Gregoire 2003; Strike and Posner 1992) places a premium on the learner's dissatisfaction with her existing understanding, and each understands this dissatisfaction as a precursor to change. Woodbury and Gess-Newsome (2002) and Feldman (2000) described that if teachers are not dissatisfied with some aspect of their teaching, they have little motivation to engage in reform and have little investment in making reform "work." But what does such dissatisfaction, Feldman's (2000) "discontent," look like? Gess-Newsome et al. (2003) explained that "pedagogical dissatisfaction results when one recognizes the mismatch between stated teaching beliefs, goals, instructional practices, and student learning outcomes" (p. 762).

Teachers' satisfaction or dissatisfaction with their professional realities stems from a variety of sources; two major sources are contextual and pedagogical. As Gess-Newsome et al. (2003) suggested, contextual (dis)satisfaction is a teacher's assessment of contextual aspects of her/his work (e.g., my room isn't big enough, I don't have enough materials, my microscopes don't work). In contrast, pedagogical (dis)satisfaction stems from the teacher's assessment of the degree to which her/his current practices achieves their teaching goals. It is the latter source of (dis)satisfaction that is the focus of this and related efforts (Southerland et al. 2010).

In order to more carefully disentangle contextual (dis)satisfaction from pedagogical (dis)satisfaction, we have elected to use Feldman's term *discontentment*. Thus, in this and related work, we describe pedagogical discontentment as the unease one experiences when the results of teaching actions fail to meet with teaching goals. Pedagogical discontentment revolves around a more internal, affective response to a personal assessment of the degree to which a teacher's practices meets the teacher's teaching goals. The construct of pedagogical discontentment is the way to conceptualize the answer to the question "Did my teaching in that lesson go well?" Note this question is subtly distinct from "Did that lesson go well?" In the latter, perhaps some technical or superficial aspect of the lesson failed to meet the teacher's standards (i.e., the computer didn't work, it took too long to distribute materials, the lesson was interrupted by the school announcements). The former question, however, focuses squarely on the conceptual and theoretical issues intertwined in pedagogy. The reflection required to respond to this question invokes an assessment of how well the fundamental structure of the lesson and techniques employed met the goals the teacher set for it. Just as conceptual change theory addresses major, organizing conceptions (Posner et al. 1982; Strike and Posner 1992), pedagogical discontentment addresses issues that are tied to the fundamental actions and ideas of teaching. Rather than focusing on the technical issues in a lesson, pedagogical discontentment extends from critical evaluation of practice in regards to meaningful learning that can occur. This deeper, more fundamental and personal consideration of practice, engenders a dissonant state that sets the precedent for change. In the literature that touches upon what we have conceptualized as pedagogical discontentment (Southerland et al. 2010), there is clearly a relationship between teacher self-efficacy and discontentment (Cantrell

et al. 2003; Gess-Newsome et al. 2003; Gregoire 2003; Saka et al. 2009a). We find it useful to highlight the future-oriented nature of the efficacy construct: self efficacy is the *forecast* about one's *potential capacity* to successfully accomplish a teaching strategy, a strategy that one believes to have the possibility of increasing student learning (outcome-expectancy) (Bandura 1993). Self- efficacy is about one's sense of one's capabilities to successfully accomplish a future task; pedagogical discontentment is an assessment if one's current and prior practices meet one's teaching goals. Teacher's self-efficacy relates to one's *future* science teaching, while pedagogical discontentment serves as an assessment of one's *current* science teaching.

Although both are related to teachers' reflections on their practice, there exists a fundamental difference between beliefs about a present state of contentment and beliefs about efficaciousness within a future scenario—and we argue that a consideration of both affective constructs is needed if we are to have a finer grain understanding of how teachers react to messages of reform—their conceptual change regarding science education reform. As Gregoire (2003) suggested, a teacher must have a degree of discontentment with the effectiveness of his/her current practices before she will thoroughly engage with and consider new teaching techniques and the conceptions that underpin them. Then she must consider that she is capable of a new approach or technique, she must have a positive sense of teaching-self efficacy, before the teacher will accept the new knowledge and attempt to employ a new teaching approach. Without pedagogical discontentment, there is little need to develop one's knowledge about teaching; without an adequate level of teaching self-efficacy, the teacher will be too threatened to undertake a new practice. In either case, we would expect few reactions or changes in actual teaching practices in response to messages of reform (Southerland et al. 2010). There is growing empirical support for this assertion, both qualitatively (Saka et al. 2009b) and quantitatively (Blanchard and Grable 2009), as researchers have found that a strong sense of pedagogical discontentment in teachers is predictive of greater gains in teachers' knowledge of reform and their use of reform-based teaching practices.

A growing recognition exists that affective constructs shape an individual's conceptual change (Sinatra 2005). Echoing this, the goal of this research is to explore a fundamentally influential affective construct that shapes teachers' learning—pedagogical discontentment—and to describe the sources of pedagogical discontentment that have been found among a variety of science teachers.

Methods

This was a descriptive study, as we sought to empirically explore a new construct; thus, qualitative methods involving two rounds of interviews were employed.

Participants

Sampling of teacher participants was based on ideas of purposeful sampling, that is, we included teachers from a range of teaching situations (e.g., grade level, science

Table 1 Demographic categories of teacher participants

Category	First round of interviews	Second round of interviews	Total
Gender			
Male	4	3	7
Female	8	3	11
Ethnicity			
European American	9	4	13
African American	2	2	4
Latino/a	1	0	1
Years of teaching experience			
1–5 years	3	2	5
6–10 years	4	1	5
11–15 years	3	2	5
15 or more years	2	1	3
College degree			
Elementary Ed	3	2	5
Second Ed	7	4	11
Science PhD	1	1	2
Grade level of school			
Elementary	3	2	5
Middle school	3	2	5
High school	6	2	8
SES of school			
Working class	3	3	6
Middle class	7	5	12

discipline, school demographics) and personal characteristics (e.g., teaching experience, age, academic preparation, gender, ethnicity) to ascertain the nature of pedagogical discontentment in a broad sense. See Table 1 for the demographic information for the participating teachers.

Interviews

Through the interviews, each of the teachers acted as expert key informants, allowing us to unearth salient aspects of how teachers recognized and expressed forms of pedagogical discontentment. The interviews were conducted face-to-face and were tape-recorded. The goal of these interviews was to holistically understand what the construct of pedagogical discontentment looked like in the teachers' particular contexts and in their own words; thus, the interviews were semi-structured, using open-ended questioning. (See interview protocol in the Appendix.) Interviews focused on the teachers' discontentment with both their current teaching practices and goals, mindful that other researchers have described that discontentment, like teaching self-efficacy, is much more fine grained and graduated than a

binary condition (Gess-Newsome et al. 2003). Thus, we conducted the interviews sensitive to language expressing either limited or minor discontentment (e.g., “Yeah, I’m not so good at that.”), as well as areas of major or significant discontentment (e.g., “I’m terrible. I’m at a loss when it comes to that.”).

We established e-mail/phone contact with the participants prior to the interview, explicating in detail the goals and purposes of the research. Participants’ understanding of the goals of the interview allowed them to better hone in on the specifics of the construct. Knowing exactly what we were trying to describe facilitated the discovery of themes that were salient to pedagogical dissatisfaction, rather than the more common, contextual aspects of dissatisfaction.

Lessons learned during the first three interviews informed the ways in which we structured subsequent interviews. In particular, the role of contextual discontentment proved to be very critical for many of the teachers. Although the goal of the interviews was to unearth the ways in which teachers recognized and expressed points of *pedagogical* discontentment, we found that discussions about more external constraints and areas of contextual dissatisfaction were very common. This was especially true during the first few minutes of the interviews in which individuals often “unloaded” a wide variety of frustrations and complaints about their working context. Recognizing this “therapeutic need” influenced how we structured future interviews. As we discuss in the next section, these conversations about contextual discontentment were often useful vehicles for bringing to light more personal reflections about internal beliefs regarding daily teaching practices.

The interviews were conducted in two phases. The first phase included 12 interviews that we used to derive our central themes. The second phase, additional interviews conducted months later, included six more teachers using the original interview protocols. The purpose of these later interviews were to assure that we had reached data saturation and that the original themes were appropriate.

Data Analysis

Briefly, our analysis of the field notes and the first 12 interview transcripts consisted of three stages (Strauss and Corbin 1998):

1. Open coding, applying conceptually meaningful initial categorization of data.
2. Axial coding, assigning categories into progressively more inclusive groupings.
3. Selective coding, selecting and identifying the core categories and systematically relating them to other categories.

We examined the major codes constructed out of the axial coding process and examined which of the selective codes accounted for the majority of the data collected for the first 12 teachers. Some of these codes accounted for data from nine to 12 of the original 12 teachers—these codes were retained: teaching science across ability levels, assessing science learning, science content knowledge, issues of depth/breadth, and implementation of inquiry-based science teaching. (Other codes, accounting for data from only four or fewer of the 12 initial interviews, included teaching with technology and managing a science classroom.) The most prominent selective codes were then taken back to the teacher participants for a member check

Table 2 Examples of emergent codes

Coding stage	Example code	Data exemplars or
Open coding	Girls and learning	Difficulties interesting girls in science Inability to get girls to speak in small group discussions
Axial code	Gender and science learning	Girls and learning Boys and learning
Selective code	Teaching science to a variety of abilities levels	Gender and science learning Ethnicity and science learning Students with exceptionality

to ensure that our interpretation of these codes represented the teachers' meaning (see Table 2 for examples of emergent codes).

Following this process, an additional six interviews were conducted (with teachers that again represented a wide range of demographic categories). These interviews were conducted to verify our selective coding process (to ensure that the categories we identified adequately accounted for these new data and that new selective codes were not needed).

Findings

Our findings reflect a wide variety of ways that science teachers recognized and expressed pedagogical discontentment within their current teaching practices. Given our limited sample, we do not assume that we have captured every possible source of pedagogical discontentment for science teachers and we do not assume that all science teachers hold discontentment in each of these categories. Instead, given their prevalence in the comments of our sample, we offer these areas of discontentment as a starting point to examine this construct. Although some sources emerged in only smaller subsets of the sample, we refrain from interpreting these as evidence of contentment in the larger sample, as the interview questions employed specifically focused on teachers' notions of discontent. We begin by discussing the five points of discontentment that were most frequently mentioned by the teachers and offered with the greatest amount of nuance and detail: teaching science across ability-levels, assessing science learning, science content knowledge, issues of depth/breadth, and implementation of inquiry-based science teaching.

Teaching to Diverse Ability-Levels: "I was One of Them!"

Adapting teaching practices for a wide variety of student abilities was the most identified place of pedagogical discontentment. Although many of the teachers spoke of the difficulties in reaching lower-ability students, they also remarked on the difficulties of maintaining challenging learning environments for those of a perceived higher-level. The teachers' discontentment revolved around teaching

science to students who were *not like themselves* with regard to science backgrounds, English language abilities, or learning dispositions as expressed by Nancy, a high-school chemistry teacher:

[The high ability students] are like me. I was not necessarily an honors-labeled student, but yeah. Um, you know, I just get a kick out of them. It's the lower-level student that I have a hard time with.

Similarly, when speaking of how her teaching resonates with her higher-ability students, Charlotte, a beginning elementary teacher, commented:

I guess the biggest thing with me is that I was one of them! I was like the little over-achiever, you feel like, "Oh, okay!" You can kind of relate to them and have a little fun.

Both Nancy and Charlotte evoke notions of being personally fulfilled through their classroom interactions with higher-ability students: "I get a kick out of them" and "I have a little more fun." Thus, it is important to note the intermingling of the two facets of *satisfaction* that Evans (1997) highlighted in her work: being *satisfied by* (pleased) and being *satisfied with* (content). One can be satisfied by, pleased by, find enjoyment with some aspect of work, encompassing a mainly affective reaction to practice. In contrast, pedagogical discontentment is an assessment of how well one has conducted an action. Both Nancy and Charlotte expressed feelings of being satisfied *by* their teaching to students who were most similar to themselves (i.e., higher-ability students)—they enjoyed teaching such students. But they also were dissatisfied *with* how they were teaching science to the lower-ability students in their classrooms; their teaching of these students did not meet their teaching goals. For the purposes of this study, we were more interested in this latter aspect: how a teacher recognized and expressed a sense of discontentment with her current science teaching strategies, an antecedent factor for conceptual change. For Charlotte and Nancy, this surfaced in terms of their perceptions that their practices were not meeting the needs of their lower-ability students.

Charlotte was also in the process of confronting the limitations of a *one-size-fits-all* pedagogy; thus, helping to further problematize her existing teaching practices.

So, the higher level [student] gets bored where the lower level [student] may be doing fine. And it's trying to find things that challenge them and try to get them to think in higher order and to think beyond the textbook, and beyond those things into what else is out there. ...I still just don't know how to reach my lower level students because... I'm trying, but it's hard.

This sentiment was shared by both novice and experienced teachers alike. Gail, a high-school biology teacher with over twenty years of teaching experience, commented:

I want to focus on those other kids without taking away from those higher achieving students. You can't say, "Oh, the high achieving students will get it anyway. Let me work with these guys." That is not what I am charged with doing, especially in an honors or an AP class. My audience, my clients, are

those kids that are high achieving. And they expect me to challenge them. So, what about the other guys? It's very frustrating.

Thus, in terms of defining the construct of pedagogical discontentment, these data did not reflect an uncertainty in these teachers' thinking about their ability to teach students of different ability-levels (something more aligned to self-efficacy). These teachers were recognizing that their current teaching practices did not equally serve a heterogeneous student population, with that heterogeneity being defined in terms of ability-levels. In other words, *what they do now* in the classroom was not adequately reaching all ability-levels; their evaluation of current practice, thus, created a point of dissonance.

Finally, Randy, a high school biology teacher who entered the teaching profession after attaining a doctoral degree in science, was also struggling with teaching to a wide variety of ability levels within the same classroom. He explained how low-ability students often act as obstacles to him teaching science as rigorously as he desired:

You know, you've got a couple of bright kids that are doing it no matter what. And then, I've got those kids that just aren't doing their work. And it gets frustrating. ...My upper ability folks ... [become angry with] the other kids that aren't...catching on. Cause [the "bright kids"] want more. And they want the steps of the Krebs Cycle. They want to know more workings of photosynthesis. They want to do Hardy-Weinberg and look at mutations. When you've got other kids that are having a hard time just taking a square root of a number. Or multiplying a number itself. They just don't get.... I just don't get it.

It was noteworthy that Randy was speaking about this ability-level issue from a rather different perspective than that of the other teachers in the study. The goal for his science classroom was to "get [the students], all of them exposed. And if they ever do come in contact with another science class, assuming they go to college, at least it won't be foreign." He was less concerned with adapting current teaching strategies for his lower-ability students than he was on teaching rigorous science content. Again, it was within a comparison of himself with his students, in terms of socioeconomic class and life experiences, through which this discontentment was fleshed out. He continued:

Because I come from an NPR, New York Times family. ... Catholic schools, upper middle-income family. Five kids, big colonial house. The whole nine yards. And you know, reading, passing all the reading tests by fifth grade. You know, that's the way that the community was.

We argue that Randy's deficit view of student abilities was less of a source of pedagogical discontentment than it is of contextual discontentment. He was not in the process of problematizing his own practice in its ability to meet his students' science learning needs, but rather, of trying to simply understand students who engaged with science (or schooling in general) in ways that seem foreign to him based on his own experiences as a very successful science student. Therefore, since

he placed the onus of responsibility for success predominately on the shoulders of his students, his teaching practices were not up for critique. Indeed, during the interview, he expressed very few points of pedagogical discontentment concerning his science teaching. It is important to point out that this analysis of Randy's beliefs about his teaching would have been less fruitful had we employed the more general notion of teacher job satisfaction/dissatisfaction. He was dissatisfied with his students (a feature of his teaching context), not discontented with his pedagogy. Indeed, Randy's comments highlight the benefits of understanding pedagogical discontentment as a distinct and bounded construct. Since our goal was to describe the boundaries of discontentment with current teaching practices, Randy facilitated this by acting as a non-example, as he spoke about problems with student ability-levels in a manner that reflects a contextual, rather than pedagogical, discontentment.

Assessing Science Learning: "That's Hard to say to a Mamma."

"Boy, the heart of it is assessment." This was David's response to questions about his own points of pedagogical discontentment. (David was a high school chemistry teacher). Indeed, assessment practices proved to be a rather ubiquitous point of discontentment for the majority of the teachers in this study. This was predominantly conveyed through talking about the limitations of their current assessment practices and the teachers' need to find alternative ways of understanding what students did and did not know. We categorized teachers' expressions of this in two lights: the means and ends of assessment. Stacey, a middle school science teacher, offered a comment that was representative of the former:

I guess this goes back to probably my education to become an educator. Different types of assessment. Like, it's what I'm very familiar with, like quizzes and tests and... A lot of times you will hear, "Oh, you can do oral assessments and assessment through drawings" and things like that. I'm not comfortable doing those types of assessments yet.

Although she problematized her own traditional assessment practices, Stacy was not expressing a high self-efficacy in terms of carrying out alternative measures. Stacey's situation is an example of the importance of understanding teachers' beliefs about current practice in terms of both contentment and efficacy. Her pedagogical discontentment was emerging from a reflection on the differences between what she is "very familiar with" and what other assessment practices are found within reform-messages.

Laura, also a middle school science teacher, extended this conversation by pointing out her own difficulties in interpreting traditional forms of assessment, using them in both summative and formative ways.

It's frustrating for them to do a paper and they get a 60 on it. Do you go back and re-teach if they didn't get it? Or are they hormonal? Or it's seventh period? Or they didn't care? It's frustrating. ... For me to know if I'm

effective, if I'm really being effective or are they really doing their part? Is it me or them?

In addition, several of the more experienced teachers spoke specifically of assessing students' learning from 'hands-on' science activities. They were quick to point out the limitations of their existing practices when it came to assessing students on laboratories or extended inquiry-based projects. Nancy (high school chemistry teacher) remarked:

I'm not comfortable with the way I assess labs. And, it's not that day-to-day assessment of, you know, are they getting what's going on in the lab, are they participating in the lab, that sort of thing. It's that culminating product, that lab report, that... Lately, I've gotten to, "Why am I making them do this?" Because, all I'm having them do is just regurgitate it back to me. And, it wastes my time because I end up grading paperwork that I don't want to grade. And so then it becomes an, "Oh, you turned it in. Great." And then I'm not even giving them feedback or looking at it.

Nancy's goal of deeply understanding students' laboratory learning was not being met through her existing strategies. Thus, she was problematizing this particular aspect of her current science teaching.

With a shift from assessment *means* to *ends*, several of the teachers also spoke about problems concerning their using and communicating the products of their current assessment practices. For example, Laura (a middle school science teacher) was experiencing a problem with how to translate the more subjective aspects of performance assessment into something "to put in a grade book." In the following quote, Laura was struggling with how to assess student learning from an inductive, hands-on activity in which students become acquainted with and employed science process skills of observations and drawing inferences:

It's hard to, to pick out a grade from...when we did the GEMS thing, we did the Ooblek [references to science curriculum materials, Lawrence Hall of Science]. You talk about science concepts. And you do. You make a little chart and you talk about vocabulary. And the kids have a scenario and then they investigate it. And they are learning! But yet, they don't have a finished project, necessarily, to put in a grade book.

Taking Laura's issue a step further, it was interesting to hear Nicole discuss the difficulties she was experiencing in communicating her performance assessment results to parents, fellow teachers, and administrators who have been accustomed to more concise, quantitative results. Although she was content with the way she herself was using alternative assessment practices with the students, her discontentment stemmed from her abilities to explain her results.

I think, most teachers probably like it more concrete. Maybe parents from old-school, they like pencil-paper things. They want the numbers and we have a system now where parents go online and check their grades every day. [But] my assessment in science is more my understanding of how they're participating, how they're working with others, and what they are learning.

Laura also mentioned this tension in terms of her use of performance assessment practices:

Which was great! You could look at the picture and say, “Okay, they don’t know what they’re doing!” Or, “They do!” ...But that’s hard to say to a mamma. So, it’s almost like you have to do one thing. It’s like ... I don’t know...

Laura was struggling with holding two simultaneous ways of assessing students: an alternative one that makes sense to her (and one that resonates with her teaching goals) and a more traditional one that she can “say to mamma.” Again, her pedagogical discontentment resided with communicating the results of her assessment practices to others.

Science Content Knowledge: “Make Sure I’m Up to Snuff.”

Not surprisingly, a perceived lack of science content knowledge was another prevalent source of pedagogical discontentment.

I’m having to make sure I’m up to snuff enough to teach the science. Just going back to review and that sort of thing. (Sonja, elementary school teacher)

We were careful to tease out issues of self-efficacy when talking about science content knowledge with the teachers. We were not particularly interested in teachers’ talking about how a shortage of content knowledge resulted in their doubting their overall abilities to teach science, thus generating a lack of confidence and resilience. However, we do see this low degree of self-efficacy as possibly beneficial in terms of teacher conceptual change (Wheatley 2002), something that we return to later in the discussion. Instead, we were focusing on ways in which teachers problematized aspects of their current science teaching through a discussion of science content. Although issues of low teaching self-efficacy were described, many of the teachers pointed to particular places within their current teaching that could be improved with more content knowledge [e.g., “I need more [science] content. I want the content and I can generate the [teaching] ideas” (Nicole, middle school science teacher).]. The generation of teaching strategies, “teaching ideas,” was related to pedagogical content knowledge (PCK) (Shulman 1987). Thus, while teachers, like Nicole, talked about this issue in terms of content knowledge, it was not this knowledge in isolation, but its role in generating relevant teaching strategies (PCK).

Not only did science content knowledge emerge within conversations regarding trying to teach rather unfamiliar material, it also surfaced as teachers’ discussed the difficulties they faced in translating their own college-level content knowledge into information that was appropriate for their students. As Charlotte (a beginning elementary teacher) remarked:

I’m kind of reading along with the kids as we go through the chapters. I’m having to remember, “We talked about that in physics class, but how do I relate it down to them?”

In particular, several of the more novice science teachers emphasized that they were presently discontented with their current means of translating/adapting their own science knowledge for purposes of teaching at the students' grade level.

The science that I learned... Because I have a biology degree. ...I'm teaching stuff on the middle school level, making sure that they get the important foundation. ...It's not like some of the things that I've learned really can even be brought down to the middle school level. (Stacey)

Recognizing that K-12 science may be different from post-secondary science (what they learned in the past) pushed Stacey (middle school) and Charlotte (elementary) to think about and to problematize their current strategies. Again, we see connections between content knowledge and pedagogical content knowledge surfacing as points of discontentment. Focusing on teachers' desires for more robust and appropriate PCK allows us to talk about acquiring more content knowledge for specific teaching purposes rather than for general expansion of efficacy.

Issues of Depth Versus Breadth: "Go Until Everybody Just Sucked the Marrow Out of it."

This particular category of discontentment was illustrative of the ways in which teachers' discussions of external constraints could be used during our conversations to unearth other more personal, pedagogical points of discontentment. For example, underlying several of the issues of external limitations to autonomy (e.g., standardized testing, national standards, time, etc.) was the teachers' discontentment with their current abilities in negotiating the tension between depth versus breadth of content. In other words, the pressures of state-mandated testing worked to problematize the teachers' current abilities to orchestrate a successful balance between covering a wide range of material and engendering deep student learning, including long term planning concerning scope and sequence of instruction. All of these issues revolved around depth/breadth concerns to some degree, as reflected by Nicole (a middle school science teacher):

If I had more time, I would be comfortable. Because that way, we could go and go until everybody just sucked the marrow out of it, you know. Cause sometimes we just don't have enough time to do that. So, it's not a lack of pulling it out of them, it's more of a "It's time to go."

Many of these teachers discussed their desire to deeply cover a topic until, as Nicole put it, "everybody just sucked the marrow out of it." But this drive for depth was countered by the awareness that there was a wide breadth of material to teach. Dissonance and discontentment thus emerge as current teaching practices were seen to fall short of achieving a balance adequate to meeting teaching goals. Although a teacher's perceptions of efficacy could be shaped by the depth/breadth issue, these teachers' responses demonstrate a confidence that they could adequately accomplish teaching the breadth of content if the contextual barrier of time were removed. The aspect of depth emerges as a critical element of the discontentment that arises between the teacher's practice and their assessment of its effectiveness.

Again, Randy (a high school biology teacher) offered a somewhat different portrait of this struggle and acts as an important non-example for our understanding of this aspect of our construct.

I have a certain curriculum that I am trying to follow.... And, um, it's just not... I'm not hitting those points as quickly as I want to. Um, because I am spending so much time going back and getting them the foundations they need. For example, in my biology class, they need some chemistry foundation and, um, and I guess just some, some reading strategies and um, some understanding some, how to solve certain problems.

Although he was concerned with depth/breadth, his personal teaching goals pushed him to teach a broader range of topics more rigorously. However, he felt stymied by having to address student deficiencies.

Implementation of Inquiry-Based Science Teaching: "It's Hard to Get There."

Finally, due to its strong prominence in national science education reform efforts (AAAS 1990, 1993; NRC 1996, 2000) and most university science teaching methods courses, we were not surprised that the topic of inquiry-based teaching also surfaced frequently during our discussions with teachers. However, research demonstrates that this approach to science teaching is very difficult for teachers to approach, both in terms of the new roles and pedagogical content knowledge it requires of them (Anderson 2007; Crawford 2007; Huffman 2006). Teachers' discontentment with their ability to "pull off" inquiry lessons was another case in which issues of efficacy were intimately intertwined, as represented by Anne's comments. (Anne was a middle school science teacher.) Although she was not perfectly content with the manner in which she incorporated inquiry-based teaching, she reflects a somewhat efficacious view of her attempts.

Well, I wouldn't say I'm dissatisfied. I'm satisfied with the rate at which I am progressing with it. I'm not completely satisfied, but I already know that I'm working, that that's an area I'm working on. And so, I recognize that's not something that happens overnight. Satisfied with my progress, yes.

Anne's dispositions concerning inquiry were representative of our assertion that a higher engagement with professional development activities may result from a level of discontentment coupled with a degree of teaching self efficacy.

Nancy's comments are more representative of how the teachers spoke of classroom-based inquiry, mainly in terms of overall frustration with current practice. (Nancy was a high school chemistry teacher):

This is my 11th year teaching and for eleven years I have started off, you know, "I'm going to do inquiry. I'm going to stick with it. I'm going to do inquiry. I'm going to do inquiry." And by the end of the first semester, I'm so frustrated. [The students are] not getting it. We're not getting through.... You know, we've gotten through two units instead of, you know, three or four. And

it just takes forever... And then I abandon it and go straight back to what I'm comfortable with, what I'm used to: lecture, lab, activity; lecture, lab, activity.

The traditional portrait of science teaching, being deductive in nature, posits that teachers should approach instruction by first explaining a concept, followed by having students experience some application of that concept in a laboratory or activity setting. However, this deductive approach is in stark contrast to inquiry-based pedagogies as discussed in the national reforms, in which students are moved toward asking questions about phenomena, finding appropriate methods to answer those questions, then generating explanations. We see Nancy's discontentment emerging from this tension between her familiarity with traditional practices in contrast to those suggested by reform documents.

Indeed, inquiry-influenced teaching and learning requires novel roles for both teacher and student, something that Stacey (a middle school science teacher) problematized within her own practice:

I mean, it would be wonderful if [students] could think of how to do experiments, to prove these things on their own. Which, I think they would be capable of, but it just... It takes a special skill to be able to do things that open-ended. Like, I've seen where a lot of people are coming from, going that direction with the open-ended things. But, it's hard to get there. You have to develop the students, step by step.

Stacey's pedagogical discontentment, stemmed from not knowing how to move students, who were accustomed to traditional and rather passive forms of learning science, into more engaged, open-ended, student-lead inquiries. Indeed, these new student and teacher roles required a certain degree of "unlearning" of (Woodbury and Gess-Newsome 2002) some of Stacey's most firmly held knowledge about, and practices of, teaching (Crawford 2007).

The Role of Contextual Discontentment

Finally, we would like to return to the theoretical distinction between contextual and pedagogical discontentment made by Gess-Newsome et al. (2003). Although our particular aim in this study was to unearth aspects of pedagogical discontentment (seeing it more directly impacting engagement with professional development activities), we found that there was a "therapeutic" role that discussion of contextual discontentment played during the interviews.

Within a number of our conversations with the teachers, there were moments when utterances such as, "I need to just get this off my chest" or "I know that this is not what you are looking for, but..." preceded sometimes lengthy cathartic interactions. Usually, these moments were filled with teachers' expressions of job dissatisfaction, related to external points of discontentment, that were acting as perceived barriers to implementing their ideals. "The other thing that is really horrible about teaching is the paperwork!" (Charlotte).

Contextual factors such as administrative support, class size, lack of materials, parental involvement, textbooks, standardized tests, etc. surfaced again and again.

We feel that these moments, although somewhat off our focus, served two beneficial functions: (a) they acted as therapeutic/cathartic/interpersonal instances when a sympathetic ear was available to listen, thus increasing rapport and (b) they generated possible venues for researchers to probe for more underlying, personal connections to specific teaching goals and practices.

This second notion, of unearthing underlying sources of pedagogical discontentment from within broader notions of contextual dissatisfaction, proved to be important throughout the interviews. For example, teachers often spoke of there being a “lack of time” to enact their desired teaching practices/goals. Although one could view this as merely an external barrier, something that is outside of the control of an individual teacher, further discussions often worked to reveal more nuanced aspects of daily teaching that they desired to improve within those existing time limitations. David (a high school chemistry teacher) brought up “time” as a point of discontentment very early on in his interview, but quickly commented. “But, I mean, time could mean anything.” When further asked what he did not have “time” to do, he went on to discuss his reasons for wanting to integrate technology into his classroom and to incorporate methods of alternative assessment, both points of pedagogical discontentment. Therefore, as stated before, the interdependent nature of both contextual and pedagogical discontentment was something that could not be ignored. Rather, it proved to be a fruitful means of revealing very specific points of pedagogical discontentment.

Teaching Experience and Pedagogical Discontentment

As discussed, all the teachers in the study at one point or another mentioned the influence of external constraints (contextual discontentment), such as time, materials, money, facilities, and administrative support. However, the more experienced teachers were able to move beyond that and reflected more readily on their own personal science teaching as places for improvement. This was not as true for the beginning teachers, who were less reflective about their own teaching and more concerned with dealing with, and surviving through, their first years.

To be honest with you, some days I go home and I’m like, “Why am I teaching?” ... It’s really, it’s really hard to pinpoint. ... It’s just so difficult to really do the best that you know in your heart that you can as a teacher. And as a science teacher, too. Because science is a difficult subject to teach. To find the time to do that and not get burned out. ... Often, I am very frustrated with the career. (Stacey, a middle school science teacher)

Russ, a high school earth science teacher, in particular, was representative of this category of new teachers. Echoing our interviews with other novices, our conversation with Russ unearthed no points of pedagogical discontentment as he spoke only of his frustrations with navigating the demands of being a new teacher. Indeed, it is perhaps unrealistic for us to expect a beginning teacher like Russ to reflect upon and problematize aspects of his own science teaching when he seemed overwhelmed by the difficult aspects of his teaching context. Disruptive students, the lack of materials, non-instructional demands, time limitations, and other aspects

of contextual discontentment bubbled up constantly within our conversations, as he lamented, "I don't know. I'm just surviving right now." When asked directly if there were aspects of his teaching that he was particularly dissatisfied with, Russ responded, "Not off the top of my head, no."

As we have seen with a few of our participants, there are issues surrounding the challenging period of induction that may hamper teachers' abilities to put aside contextual discontentment and reflect on their own knowledge of teaching and their practice (Luft and Patterson 2002). Because novice teachers are often overwhelmed with the immediate need to learn to negotiate complex, contradictory contexts and demands (Saka et al. 2009a, b), personal reflection on their own teaching knowledge practices may be beyond their reach without sustained support.

Discussion and Implications

We turn now to what we, as teacher educators, can "do" with this construct of pedagogical discontentment. Change of any individual can be difficult. Models, such as the Concerns Based Adoption Model (Loucks-Horsley and Stiegelbauer 1991), are attempts to account for the concerns individuals might have about the proposed change, suggesting that the questions teachers ask about the change begin with the personal ("what does this mean for me?") then move to the practical ("how might I do this?") and then move to the consequential ("what does this mean for my students?"). This resonates with the work of Gregoire (2003) who suggests that teachers' consideration of a new practice requires them to view the change as a promising challenge instead of a threat. However, before the consideration of "what does this mean for me?" conceptual change theory would suggest that a teacher must have a sense of dissonance about one's current teaching practices if they are to thoroughly consider a new practice (Feldman 2000; Gregoire 2003; Woodbury and Gess-Newsome 2002).

Gess-Newsome et al. (2003), and Gregoire (2003) posited that a state of receptivity and openness is highly essential to a change in teaching practice. To date, much of the consideration of affective factors influencing change has focused on teachers' motivation, interest, and teaching self-efficacy (Brand and Wilkins 2007; Rice and Roychoudhury 2003; Scharmann and Orth Hampton 1995). Yet, both Wheatley (2002) and Settlage et al. (2009) acknowledged that the teacher education community has used an overly simplistic interpretation of the value of self-efficacy. Indeed, these authors suggested that overly or artificially high teaching self-efficacy may prevent teachers from seeking change. They argued that having a degree of low self-efficacy (a doubt of efficacy) may actually push teachers toward reflection. We argue this time of reflection allows teachers to assess the effectiveness of their current practice (as opposed to their assessment of their future abilities). By allowing for reflection on "how my teaching in that lesson just went," teachers open the door to pedagogical discontentment—and thus, they begin the process of refining what they know and do in their teaching.

The common areas of discontentment for the teachers interviewed in this study included the ability to teach all students science, science content knowledge,

balance depth versus breath of instruction, implementing inquiry instruction, and assessing science learning. Clearly professional development experiences should be developed to focus on these constructs if we are to precipitate change in classroom practice. But we realize that the sources of discontentment and their strength are likely to vary as a teacher's knowledge, practice, and teaching context change and develop. Specific professional development considerations must remain sensitive to the participants and their contexts (Crawford 2007; Loucks-Horsley and Stiegelbauer 1991). This sensitivity must include understanding teachers' discontentment with their enacted pedagogy, and in related research we have developed an instrument to allow for the measurement of this discontentment on a large scale (Southerland et al. in press). The sources of pedagogical discontentment identified here, although drawn from a limited pool of teachers, represent challenges for reform that remain prevalent.

Just as the Concern Based Adoption Model (Loucks-Horsley and Stiegelbauer 1991) suggests that teachers must be supported in answering specific forms of questions before they can reasonably consider a new practice, we argue that professional developers should be mindful of a teacher's state of pedagogical discontentment at the outset of a professional development experience. If the focus of a professional development experience may conflict with teachers' more traditional understandings of teaching and learning, this line of research posits that professional developers must capitalize on teachers' pedagogical discontentment or include ways to catalyze discontentment in teachers. Until teachers become discontented with their current understandings of teaching and the results they engender, close consideration of new ideas and practices is unlikely. We suggest that effective professional development must build upon or foster pedagogical discontentment, which could be accomplished by showing teachers a portrait of what is possible in terms of some aspect of their teaching practice and allow them to reflect on their own efforts in this area before structuring time to deeply engage in the new concept or practice. Professional developers must consider teachers' affective states at the outset of a professional development experience, and we suggest that pedagogical discontentment is a central aspect of that state.

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Appendix: Interview Protocol

Personal/Contextual

1. How long have you been teaching?
2. Where/what subjects have you taught?
3. Where (what context) have you been the most satisfied?
4. Can you talk some about your past science experiences?

General Discontentment/Change

5. Are there aspects of your teaching that you are not completely satisfied with?
6. Where do you turn to for new information/solutions to teaching situations/problems that come up?
7. How would you know/recognize when something is successful/effective in your classroom? What signs would you look for?
8. How would you know/recognize when something is *not* successful/effective in your classroom? What signs would you look for?
9. How would you react to those signs?
10. Describe any constraints that you feel are preventing you from achieving your science teaching goals? (allow for both internal and external; probe internal)(re-read context)

Goals/Ends

11. What are some of your overall personal goals as a teacher?
12. What are some personal goals that are specific to your current teaching context (i.e., student populations, community, etc.)?
13. What are some personal goals that are specific to science learning?
14. Explain/describe any discrepancies between your personal goals and what you are able to currently achieve in your science classroom?
15. How well do you think your personal goals/external goals are beneficial to all of your current students?
16. Explain/describe the alignment with your personal teaching goals and the goals put forth by the curriculum or by national and local science/teaching standards? Conflict?
17. What words would you use to describe the feeling that there is a disagreement between your personal goals as a science teacher and the goals set forth by national/local science standards and/or administrative/school contexts? How would you describe this to a fellow teacher/colleague?

Instructional Strategies and Practices/Means

18. Currently, are there particular kids (or groups of kids) that you're particularly good at teaching/reaching? Some that you are not?
19. Do you feel that your current teaching practices/strategies equally reach all of your students?
20. Where/how/when do your science teaching practices not fully become effective or successful?
21. Where do you find more discontentment: your science teaching goals or the practices/means you have of achieving those goals? Can you elaborate?
22. How would you explain the discontentment you feel with your current teaching practices to another teacher? What specific words would you use that you feel would resonate with other teachers?

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