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In this paper we outline C. S. Peirce's four ideas about how beliefs become fixed, or stabilized, as well as his concept of genuine doubt with respect to teacher beliefs. We then describe an abductive reasoning process that illustrates how a person resolves doubt. We use a case example of a teacher experiencing doubt and resolving it through the abductive reasoning process to illustrate both our thinking and the utility of the process. The data for the case example were captured in an online learning community based on active teacher inquiry into personal beliefs and practices. We argue that, as such, the community serves to irritate teacher beliefs and support teachers as they experience and work to resolve genuine doubt. We conclude with a discussion of the importance of genuine doubt and abductive reasoning in teacher education.

Introduction

The purpose of this paper is to discuss teacher beliefs from a Peircean semiotic view. While others have examined beliefs from various viewpoints (e.g., Apple Computer, Inc., 1992; Dwyer, Ringstaff, & Sandholtz, 1991; Ennis, 1994; Kagan, 1992; Nespor, 1987; Pajares, 1992; Richardson, 1996; Rokeach, 1968), we feel that Peirce's ideas about belief fixation and transformation provide a unique lens for analyzing and understanding teacher beliefs.

We begin with an examination of Peirce's view of beliefs. We then describe a reasoning model to illustrate our position that teachers follow a process of abductive reasoning when they engage in problem solving to resolve doubt—a process that includes altering beliefs. We illustrate our position and the reasoning process with a case example in the form of teacher statements. The statements, made by a practicing educator, were captured during her year-long engagement in an online community of practice that promotes revealing and challenging underlying beliefs and assumptions and resolving doubt. We conclude with a discussion of the usefulness and importance of a Peircean viewpoint for both teacher education and professional learning.

We begin with Peirce's statement "Our beliefs guide our desires and shape our actions" (CP5.371).[1] To start here is to lay the foundation of how teachers may act within their classrooms and interact with students. Beliefs are at the core of reflexive and customary decisions of practice that are often set in motion with the best of intentions. For example, a teacher gives a spelling test each and every Friday with the belief that spelling tests ensure that students can spell. Even when the students fail to spell the words from the spelling lists in written stories, letters, and posters, the teacher holds fast to the notion that spelling tests increase learning to spell—a customary, some might say illogical, decision of practice. Or, a teacher may have a concern about a student's progress and make decisions based on beliefs about teaching and learning that he is semi- or wholly unaware are driving his actions.

1. As is common in Peircean scholarship, quotes and citations from Peirce (1931-1958) will be identified by volume and paragraph number.

Considering this and other common instances of beliefs driving actions, we asked ourselves: "Why do we hold on to beliefs?" We hold on to beliefs because they are a "calm and satisfactory state which we do not wish to avoid or to change" (CP5.372). Change is painful and irritating to the human condition. Teachers, being all too human, enjoy the satisfactory state of predictability within their classrooms as each day, month, semester, and year goes by. As Pajares (1992) stated, "People grow comfortable with their beliefs" (p. 317).

Since, as we have noted, beliefs tend to persist in spite of evidence to the contrary (Hall & Loucks, 1982; Kagan, 1992), it is important to consider where beliefs come from and how they function in our lives. Here we argue that beliefs form the base state of cognition through which we make sense of the world (Cunningham, 1998) and that we have no knowledge that was not first part of our belief system. In fact, we establish and stabilize our worldview of beliefs through a process that Peirce characterized as "fixation of belief." Beliefs are our stability, even when they prove to be insufficient or illogical, and therefore they persist. Yet, even though beliefs are highly resistant to change, they are modifiable. Understanding how beliefs can be changed or modified and what that change looks like warrants investigation.

Peirce proposed that we create or accept new beliefs when we are in a condition of inadequacy that he called "genuine doubt" (CP5.443). This state of genuine doubt arises from experience; hence it is naturally imbedded in a relevant context or situation. Being in a state of genuine doubt can be uncomfortable, painful, and irritating and therefore can compel us to create new beliefs or alter existing beliefs to move to or establish some new state of belief. Being in the state of genuine doubt is distinct from Descartes' methodological notion of skepticism which Peirce saw as conjectural or "pretend" doubt. That is, Peirce felt that Descartes, in his method of skepticism, never really doubted anything that he did not mean to ultimately restore. For example, Descartes claimed to doubt the existence of God, but he did not stop using his method until he could claim that the existence of God was necessary. When we are in doubt we struggle to attain a state of belief; Peirce termed this "inquiry" (CP5.374).

Peircean Semiotic View of Beliefs

Peirce (1877) proposed four methods through which we can fix beliefs: tenacity, authority, a priori, and experiment. We will discuss each method in turn. The first method, tenacity, occurs when we hold on to a belief in the face of doubt in order to preserve a self-identity or a world view to which we are committed. As former K-12 teachers and present teacher educators, the authors have personally observed how good a teacher can be at holding onto an existing belief even in the face of contrary evidence. Kagan (1992) noted that this tendency to hold on to beliefs exists because teacher beliefs form a particularly provocative form of personal knowledge that rarely changes even after extensive teacher education. In fact the beliefs that they hold once they graduate from the university are most likely the same beliefs that they held before they entered their undergraduate program. That is because the beliefs that teachers hold are rarely influenced by reading and applying the findings of educational research (Hall & Loucks, 1982). In addition, Peirce stated that sometimes they [people] are quite like the ostrich and feel quite safe holding their head in the sand (CP5.377). As teacher educators, we must not only accept the responsibility for this disturbing phenomenon, but face the fact that what we are doing, and the ways that we are doing it, appear to have little impact on the beliefs of the teachers that our programs produce.

The second method of belief fixation, authority, occurs when we accept the beliefs of authority figures, such as parents, experts, or members of a community with whom we identify or want to identify. Authority fixation develops within teachers from a number of sources. Some preservice teachers enter schools of education with authority fixations developed through interactions with the teachers that they had and observed during their elementary, middle, and high school years. When preservice teachers arrive at the university, more times than not they receive lectures about what they should do, and in the process, teacher educators become the new authority figure. In other words, in our teacher education programs we tell our students what to think and what to believe, using the authority of our role as professors of education. Pierce would see us as fanning the flame of authority fixation. Thus, preservice teachers learn in their undergraduate program, as they learned through their K-12 school years, that authorities hold certain beliefs and it is wise to adopt them. This leads to one of the most troublesome aspects of authority fixation of beliefs. Through authority fixation, some preservice and inservice teachers may become, "intellectual slaves" (CP5.380), thinking and believing what they are told to believe and think. Yet, the realities of today's classrooms demand teachers who can challenge both their own thinking and practice and the thinking and practices of others in order to produce the best learning environment possible. To produce that caliber of teacher, we must design programs that foster and support their ability to reveal, challenge, and if need be, alter the beliefs that they hold. In other words, we must find ways to help teachers see that beliefs are personal and that each person has within herself the power to alter those beliefs.

The third method of belief fixation, a priori, is invoked when our beliefs change in the context of an already existing structure of beliefs, such as philosophical, scientific, or cultural preferences or ideas. Here we resolve our doubt by seeking a conceptual coherence, a commitment to the worldview that has served us well so far. As Peirce states, it makes inquiry similar to that of taste, and taste is based on the fashion of the time. An example in education is the pendulum swing (Slavin, 1989), where programs are purchased and then thrown out as if they were clothing styles. For instance, during the 1960s and 1970s a number of reading specialists believed that reading comprehension resulted from teaching separate decoding skills (Fries, 1962). During the late 1970s and early 1980s, educators began to believe that the best way to develop literacy was to identify a set of comprehension skills, and reading instruction in many classrooms became the teaching and practice of these discrete skills (Otto, 1977). Today, discrete skill progression has gone out of fashion as educators apply the latest research to focus on comprehension in the broad perspective of literacy learning (Clay, 1979, 1991; Teale & Sulzby, 1986). Yet all of these reading approaches are sold to teachers as the technique de jour, the best practice. Too often, those best practices become the dogmas of tomorrow that are out of fashion and provoke another round of teacher training in the new and "latest" technique. In other words, each new technique is delivered to teachers as a whole package, a priori beliefs included.

The three methods described so far, tenacity, authority, and a priori, all resolve doubt and fixate belief by opinion—stubbornly maintained, taken from others, or reasoned from premises through experience. The examples given provide what some would call improper forms of beliefs. These three types of beliefs can have proper forms under certain circumstances. A tenacious belief, that the authors have, is jumping off a building will hurt and so we avoid the behavior. Authorities can be repositories for the resolution of genuine doubt. When the first author is working on certain aspects of

Peircean philosophy, he contacts authorities in cases of doubt concerning Peirce's meaning. An important aspect of these beliefs is they are energy saving because altering a belief takes a great deal of energy. These three types of beliefs can be so ingrained (in a positive way) that there is no need to test the belief.

There is a fourth method, however, known as experimentation and Peirce preferred it. In Peirce's experimentation, one seeks to remove doubt by collecting more and more observations, generating potential hypotheses to account for experience and, finally, reaching a conclusion based upon an inferential process. Experimentation entails skepticism, openness to alternatives, discernment, negotiation, cooperation, and compromise to fix or stabilize beliefs (Cunningham, 2001). But teachers do not tend to experiment when confronted with a situation that causes them concern. Rather, they tend to react to symptoms or concerns in a specific way. For instance, Moss (1999, 2000) found that teachers commonly see a classroom concern or symptom as the same as an underlying problem. Without the disposition to search for contributing factors, they often rush to correct those concerns rather than engage in a process of systematic and intentional inquiry into the nature of the concern and the problems that underlie it. In other words, teachers see their classroom concerns as problems to be corrected rather than as invitations to reflect and learn (Moss, 2001).

For this reason, we agree with Peirce that there are distinct advantages to using experimentation to resolve doubt. The complex realities of the classroom increasingly call upon the teacher education programs to prepare teachers to be lifelong learners and scholars of their own practice. But to realize this vision, teachers must be able to examine their belief systems in a reflexive way, they must be able to conduct belief maintenance. By maintenance, we mean the continual reflection on beliefs. We feel this is important because revealing and under-standing your own beliefs is harder than it looks. It is hard because resolving doubt is uncomfortable and takes energy.

The State of Genuine Doubt

How do we foster this disposition towards inferential reasoning? As previously stated, we argue that beliefs change when we are confronted with genuine doubt. In order to harness the power of genuine doubt, we must first get a handle on two things: 1) What happens when teachers experience genuine doubt? and 2) What does it look like when our beliefs are changing?

One premise is that when we are confronted with "genuine doubt" we are compelled to use the skill of abductive reasoning. It is one of three interdependent modes of reasoning that Peirce proposed, and to understand any one it is important to consider all three modes of reasoning: abduction, induction, and deduction.

> Deduction is the only necessary reasoning. It is the reasoning of mathematics. It starts from a hypothesis, the truth or falsity of which has nothing to do with the reasoning; and of course its conclusions are equally ideal. The ordinary use of the doctrine of chances is necessary reasoning, although it is reasoning concerning probabilities. Induction is the experimental testing of a theory. The justification of it is that, although the conclusion at any stage of the investigation may be more or less erroneous, yet the further application of the same method must correct the error. The only thing that induction accomplishes is to determine the value of a quantity. It sets out with a theory and measures the degree of concordance of that theory with fact. It can never originate any idea whatsoever. No more can deduction. All the ideas of science

> come to it by way of Abduction. Abduction consists in studying facts and devising a theory to explain them. Its only justification is that if we are ever to understand things at all, it must be in that way. (CP5.145)

Unfortunately, we have relied almost solely on induction and deduction in our teacher education programs. Our students are told what they need to know and encouraged to try out their knowledge in the world of their experience or on tasks that we contrive (i.e., student teaching). Certainly, those kinds of experiences are important and need to be nurtured, but they are not enough. While these traditional experiences encourage both inductive and deductive reasoning, they do little to bring beliefs into question in a way that might cause changes in those beliefs. One reason may be that traditional experiences do generate meaningful cognitive dissonance or discomfort and therefore are ineffectual means of promoting genuine doubt and, therefore, abductive reasoning. Our contention is that fostering a disposition toward healthy skepticism and experimentation that could result in teachers investigating and altering their beliefs seems to involve the process of abductive reasoning during genuine doubt.

Ten Modes of Reasoning

To understand the pivotal role of abductive reasoning, it is important to situate it in an elaboration of Peirce's reasoning types. Shank and Cunningham (1996) have elaborated Peirce's types of reasoning by identifying six modes of abduction, three modes of induction, and one of deduction. The full derivation is too detailed to describe here (see Shank, 1994) but can be illustrated based on research by Arici, Schreiber, and Cunningham (1998) and Cunningham, Arici, Schreiber, & Lee (2002). We will use this research to describe each reasoning type and illustrate each type through the context of a student conducting an information search on the WWW (Cunningham, 1998).

1. Omen/Hunch[2] (or Rhematic Iconic Qualisign). This type of abductive inference deals with the possibility of a possible resemblance or reasoning in order to determine the possibility that our initial observations might lead to possible evidence. An omen is a sign whose resolution is in future acts of inquiry and observation. When the inference of the omen is more implicit, we might call it a hunch. For instance, when students search for information on the WWW, we often observe them linking to sites because they hope to find leads to more relevant sites. One student thought that the topic of dropouts might come up in a sociology class and searched for a relevant web-based class at Indiana University.

2. Symptom (or Rhematic Iconic Sinsign). A symptom is a sign whose action is ongoing in the present and we infer from the symptom the presence of some more general phenomenon. This type of abductive inference deals with possible resemblances, whether or not some actual observation has enough properties to be considered as relevant to some case. For instance, our web surfer must decide if an item of information is relevant to her search parameters and, therefore, whether it is worth following. Is a link about truancy likely to be relevant to the topic of school dropouts?

3. Metaphor/Analogy (or Rhematic Iconic Legisign). This type of abductive inference deals with the manipulation of resemblance to create or discover a possible

2. Gary Shank continued to develop and refine this model. See Shank, G. (2001). It's logic in practice, my dear Watson: An imaginary memoir from beyond the grave. *Forum Qualitative Research, 2*(1). Online at http://www.qualitative-research.net/fqs-teste/1-01/1-01shank-3.htm

rule. It is the mode of inference that uses analogy and metaphor to create new potential rules of order. For example, suppose our web surfer is having little success locating information about school dropouts. If she regards the problem as similar to that of runaways, she might be able to move forward by following this related theme.

4. Clue (or Rhematic Indexical Sinsign). This type of abductive inference deals with possible evidence, one reasons in order to determine whether or not some observations are clues of some more general phenomenon. Unlike the symptom, the clue is a sign that indicates some past state of affairs that has led to the clue. For instance, is the increase in teen pregnancies a clue to the cause of school dropouts?

5. Diagnosis/Scenario (or Rhematic Indexical Legisign). This type of abductive inference involves the formation of a possible rule based on available evidence, proposing plausible hypotheses or scenarios from the body of clues. Our web surfer is now moving toward tentative accounts of the cause of dropouts and is attempting to unite these accounts in a more unified form like a narrative or scenario.

6. Explanation (or Rhematic Symbolic Legisign). This type of inference deals with a possible formal rule, reasoning in order to form a general plausible explanation. This form of abduction seems closest to what Josephson and Josephson (1994) call "reasoning to the best explanation" (p. 5) or that a body of information provides evidence for a hypothesis that explains or accounts for that information. So if our web surfer, based upon the available information, has proposed an explanation for school dropouts that is consistent, coherent, parsimonious, etc., then doubt can be reduced.

7. Identification (or Dicent Indexical Sinsign). Our first category of inductive inference tests for actual evidence of a particular thing. Here we are testing whether an observation is an instance of X, where X is something already assumed. In more scientific parlance, this might be called construct validation. Our web surfer might test her emerging concept of school dropouts by making observations as to whether her definition includes those who should be included and excludes those who should not.

8. Prediction (or Dicent Indexical Legisign). This mode of induction reasons from actual evidence of a probable rule. When constructs are linked in some causal or covariate relationship, our observations can be used to test the veracity of the relationship. In formal settings this might be referred to as hypothesis testing. For example, our web surfer might locate information that supports her hypothesis that school dropouts have lower self-esteem than those who do not drop out.

9. Model building (or Dicent Symbolic Legisign). If our inductive tests lead to a probable conclusion based upon a rule or set of rules, we are building models. When rules form a coherent whole and create a structure from which actual experience can be tested, then habits, models, or world views emerge. A common scientific framework for this sort of inquiry is called convergent validity. Our web surfer may be able to validate a coherent body of research from which she can predict and test causes of and interventions into the school dropout problem.

10. Formal reasoning (or Argument Symbolic Legisign). This last mode is deductive reasoning where a necessary conclusion is reached based upon formal rules. Here our web surfer might link hypotheses, such as the one mentioned above concerning dropouts and self esteem, for further inductive and abductive reasoning.

Each of the six modes of abduction deals with potential or possibility, each of the three modes of induction deal with actuality, while deduction focuses on rules and regulations. It is the modes of reasoning, the inferences that we make, that emphasize possibilities that are essential to successfully resolving

genuine doubt. When we are trying to resolve doubt (i.e., solving a problem), we are following hunches and looking for clues, building scenarios and coming up with tentative explanations. We have to sharpen our skills to learn which symptoms are important or to be trusted and which are irrelevant or red herrings. Abduction alone, of course, is not sufficient. Ideas must be linked by reason to other ideas and tested. But how might we lead teachers into this process and support them once they are involved? One answer is to develop programs and processes that act as "belief irritators."

Irritation of Beliefs

How can we lead teachers into genuine doubt? And, if we can lead them there, can we increase our understandings about how beliefs change? These questions have plagued our work and research in different ways over the last decade. One program, Teaching as Intentional Learning (TIL) (Moss, 1998), has become a context rich environment for investigating our question. TIL is an online community of practice where educators engage in a process of "systematic and intentional inquiry" (Moss, 2001) known as the TIL Process. Moss (2001) describes systematic and intentional inquiry in this way:

> In its most basic form, systematic and intentional inquiry is driven by an educator's curiosity, interest or passion to understand and address an area of concern. Inquiry begins as an educator notices something that intrigues, surprises, or stimulates a question. What the educator experiences or observes often does not make sense in relationship to the educator's previous experience or current understanding (Cochran-Smith, 1995; Cochran-Smith & Lytle, 1993; Lytle et al., 1994; Zeichner, 1994). By seeing that concern as an invitation to learn, [the educator] takes action through observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models.
>
> Because this kind of learning originates with a unique area of concern, each educator must take his or her own idiosyncratic pathway through systematic and intentional inquiry. It is hardly ever a linear progression, but rather more of a back and forth or cyclical series of events. As the inquiry process unfolds more observations and questions emerge, giving occasion for deeper interaction and integration of contributing factors while increasing the potential for further development of understanding. Along the way, the [educator] is collecting and recording data, making representations of results and explanations, and drawing upon other resources such as research, theories, effective practices, web resources, books, videos, and colleagues. Making meaning from the experience requires intermittent reflection; conversations and comparison of findings with others; interpretation of data and observations, and applying new conceptions to other contexts as [the educator] attempts to construct new mental frameworks of teaching and learning. (p. 6)

Each member of the Teaching as Intentional Learning community agrees to see a concern as an invitation to learn rather than as a problem to be corrected (Moss, 1999, 2001). Members of the TIL community, supported by the TIL process, constantly act as belief irritators and collegial skeptics—continually asking questions, challenging both explicit and underlying assumptions, and providing alternative viewpoints and paths to travel as members try to resolve doubt. One component of TIL is helping teachers reveal and understand their

beliefs and develop belief maintenance skills and resolve doubt.

As we examine online conversations captured in TIL's bulletin boards, chats, and periodic learning reports, we find that the educators employ the 10 reasoning modes proposed by Shank and Cunningham (1996). We have also seen this in other areas such as problem solving (Cunningham, Arici, Schreiber, & Lee, 2002; Arici, Schreiber, & Cunningham, 1998; Schreiber, 1999). Specifically, teachers and those involved in other studies follow hunches and look for clues about what might be relevant to their concern and where to find relevant information. Using strategies like metaphor and analogy, they pose tentative explanations and scenarios that they can examine for compatibility with others and mine for new paths to relevant information. Eventually, a conclusion is drawn. Through all of this, members of the Teaching as Intentional Learning community spend a great deal of time using abductive strategies.

A Case Example

The data for this paper came from periodic progress reports filed by one member of the TIL community, a practicing teacher, enrolled in a graduate course of study. Her reports were guided by a series of prompts tied to an analytical scoring rubric. The prompts—which remained the same for each progress report—asked her to describe an area of concern that emerged from her classroom practice; to describe the professional learning agenda that she was pursuing in order to identify factors that contributed to that concern (underlying problems); to reveal and challenge personal assumptions about the teaching-learning process relative to that inquiry; and finally, to describe how the learning that resulted from her systematic and intentional inquiry connected to her daily classroom practice (Moss, 1998). Each statement, presented as data, represents an excerpt from one of her progress reports and was filed online to the course instructor, graded against the rubric, and followed with specific feedback.

The statements are set up in blocks and within each block there exists a setup introduction that provides contextual anchors for each statement. We follow each statement with a discussion that highlights the abductive process. Natasha's statements are direct quotes from the progress reports. Note grammatical errors have not been corrected.

Block 1

Setup: At the beginning of her experience, Natasha is trying to understand her new role as a teaching coach after functioning as a classroom teacher for over a decade. She is also trying to determine the validity of a new reading program implemented in her district. She uses her concern about her new role and the new reading program to create a professional learning agenda that might support her efforts to coach teachers in this new reading program through her new role.

Natasha's Statement: [I am in] a new position and I have a lot to absorb. Currently I have been examining the key principles. I believe I will look at Learning and Cognition, Motivation and Classroom Leadership, Assessment and Evaluation, Instructional Organization and Delivery to start. This seems like a huge amount of "stuff" to look at, maybe I am crazed! But I do not know for sure what to look for.

Discussion: As one can see, Natasha is in a state of doubt both about her new position and about how to find information about what she will need to know. She sets the parameters of her search by designating general informational resources in the TIL online learning environment. This is an excellent example of the omen/hunch mode. Using this mode, one looks in a particular

spot because he or she thinks pertinent information exists there. It is only in future acts (reading the information provided through the websites, asking questions to other members of the TIL community) that Natasha will find out if any of these information resources will provide useful evidence.

Block 2

Setup: Because of the dual nature of her concerns in Block 1, Natasha is also trying to understand aspects that are important for reading instruction. In this next excerpt she expresses a concern about the teaching of reading.

Natasha's Statement: I fear that we are not effectively instructing students to be critical readers. ... In light of this belief, I have great concerns after spending time in schools. I do not see many teachers who actually care to learn the background research which would provide the instruction that students need. I still am finding resistance in teachers ...

Discussion: For Natasha, the teachers' reactions and actions are an ongoing concern and are impacting reading instruction. When a sign like this is in the present and it may be relevant to the situation at hand or other situation, it is a symptom. Similar to a running nose being a symptom of a much deeper situation, a cold or allergies, the teachers' reactions are a present symptom of a more general phenomenon. For instance, the teachers might be overwhelmed or troubled by recent changes in how they are evaluated and, therefore, are not as open to new ideas.

Block 3

Setup: At this point Natasha has used several paths to support her inquiry. She has done some reading, interacted with members of the Teaching as Intentional Learning community and spent time engaged in general information searching. She is trying to reconcile her understanding of unfamiliar concepts that she feels might be pertinent to her concerns.

Natasha's Statement: Even mathematics relies on reading skills. ... I found several web sites that dealt with "self efficacy," an new concept to me. I went to www. emory. edu first. There I began to clear up my understanding of the concept. The article helped me clarify my thinking. Interesting how our beliefs about specific aspects of ourselves powerfully influence our potential. I have been equating it with me losing weight. I could write a book about losing weight.

Discussion: In the first comment about mathematics, Natasha is trying to understand and communicate the importance of reading skills. For her, mathematics and reading compose a juxtaposition. Placing these content areas side by side for contrast and comparison helps Natasha begin to conceptualize her concern and the new material.

The second comment is clearly an analogy to personal experience. In this comment she is grappling with the concept of self-efficacy by drawing a comparison to her experience with weight loss. But even at this point Natasha is still in genuine doubt about the multiple concerns that she is trying to understand and what the underlying problems that contribute to those concerns may look like. In considering the statement concerning self-efficacy, one will quickly notice that searching for information on self-efficacy may have come from a hunch. This is a good example of how a hunch can lead to an analogy. As we seek to resolve doubt through the abductive reasoning process, one mode of abductive reasoning can lead to another because she is linking signs. It is important to note, however, that although one mode of abduction can lead to another,

the modes do not work in a linear or prescribed way when we seek to resolve doubt. In fact, during the abductive reasoning process we use all of the modes in varying degrees and at varying times.

Block 4

Setup: After a great deal of inquiry (Block 3) through reading, classroom observations, discussions with teachers in her district, interactions with Teaching as Intentional Learning community members, and examinations of a variety of theoretical perspectives, Natasha is now finding information and concepts that she feels may be helpful to her.

Natasha's Statement: I fear that we are not effectively instructing students to be critical readers and writers. In light of this belief, I have great concerns after spending time in schools. I do not see many teachers who actually care to learn the background research which would provide the instruction that students need. I still am finding resistance in teachers ... I think too many teachers have little faith in the children they teach. They feel negative about their ability to change the lives of students. Many are very controlling with their classes and never allow children to have any input into the class. I have observed this over and over in the past 10 years. I have read these because they pertain to my concern with reading instruction.

I read the state of Texas' report on beginning reading instruction. The beginning of the article does lend support to word building and syllasearch ... It talks about systematic decoding strategies, which word building and syllasearch are. This article supports reading A LOT to increase vocabulary development, ... I also have been concerned with understanding exactly what I believe about the teaching learning process.

Discussion: All of Natasha's comments hinge on pieces of information that are not current in the same sense as a symptom. Many of them are past tense, in the sense that they existed before Natasha "found" them. The first comments concerning teachers not caring and being resistant indicate a past state of affairs that may be possible evidence of what her role as a teaching coach will need to be. The next two comments both deal with clues relative to reading instruction and what form it should take. Natasha, is now linking pieces of information, specifically what she is currently learning and experiencing and what her district has stated is important. Her most significant clue may have been the acknowledgement that she does not know what she believes about the teaching and learning process. Therefore, she is clearly in a state of doubt concerning her job role, her ideas about the new reading program, and what she actually believes about the teaching learning process in general.

Block 5

Setup: As Natasha continues her inquiry through reading information (Block 3) and talking to members of the Teaching as Intentional Learning community through the online bulletin boards, she is beginning to put some of the clues together.

Natasha's Statement: I looked at several brief articles I discovered. ... They helped me begin to sort out the differences between Whole Language approach to instruction and Phonics based approach to reading instruction. I find the whole thing intriguing because these two ideas about instruction seem so easy to integrate.

I am starting to believe that a mix of whole language techniques and phonics based instruction may be the way to go, a balanced approach. But I have to continue my search of this so I can be the expert.

Discussion: Natasha has begun to create a simple scenario concerning just two philosophies of reading instruction that she has encountered. Instead of seeing them as opposite or choosing one or the other, she feels that a combined, balanced approach may be better. In essence, she is beginning to see relationships among approaches that might help students learn to read. Yet, even as she is progressing toward a more sophisticated view of learning to read, Natasha is only at a scenario stage in the abductive reasoning process. She does not have an explanation yet as to why a more balanced approach could be used to test with inductive reasoning.

Block 6

Setup: The next statement was made after Natasha experienced a major collapse of what she felt she knew. Specifically, she doubted herself and what she believed to be true. She did not discard her previous work (Blocks 3-4), but clearly was not sure of what path to take.

Natasha's Statement: I need to be able to find out all I can. But in the search I am getting lost. I don't know what to believe. ... I am getting really confused about what it is that I believe. One day I think I have it all together and the next I feel like I do not belong in this field.

Discussion: It is apparent that Natasha is again in genuine doubt. What is different is that this time the genuine doubt appears to be more severe. The first time she experienced genuine doubt, she expressed uncertainty about her new job and the reading program that was being implemented. This time, she expressed doubt about her own overall effectiveness as an educator. After making this set of statements, Natasha began researching again and urgently engaging people in the online community. In other words, her genuine doubt drove her to re-engage in the abductive reasoning process.

Block 7

Setup: Natasha is now beginning to look into other theoretical frameworks within the Teaching as Intentional Learning community for possible resources and information. She is at the height of her doubt and is actively seeking ways to resolve it.

Natasha's Statement: Perhaps this [Pre-K] program needs to be improved to give low SES students a better start than it currently is. I guess I need to look further into early intervention, I don't quite understand how to make up for language deficiencies. ... I also am going to try to delve into teacher change. I do not know what is available, but I am going t find out. I have been given some names to check into, and places to find them. Hopefully I am heading myself in the right direction.

Discussion: These new possibilities are hunches for Natasha. She is not sure if she will find the information she wants but feels that these areas will provide her with a start. Secondly, she is still dealing with two problems, how children learn to read and what her role might be in facilitating change and improvements in reading instruction among the teachers with whom she works. With regard to her role, she is now thinking that understanding teacher change may be important. So this is also acting as a clue; that is, it might help her to understand how teachers change since this knowledge may aid in her understanding the teacher resistance that she is observing.

Block 8

Setup: After Natasha completed more inquiry in several areas (Block 7) and entered into a variety of online discussions,

she began to find pieces of information that may be helpful in coming to a resolution.

Natasha's Statement: I read some more about reading instruction. Maybe more about language acquisition. I am beginning to think about how we acquire language early in life. I wonder how to work with students who do not have much interaction with literate adults speaking with them. I suppose these kids might be behind peers who have lots of opportunities to speak and listen to adults speak. Perhaps my reading concern is growing to look further at how to best serve the children who start school behind their peers.

I also want to start looking into language acquisition. Yesterday, a presenter said something about this being all about language. It has me thinking about how people acquire language and how to best foster language development in children, particularly low SES children who do not have many opportunities to have rich language experiences early in life. I have found that many quotes have struck chord with me. For example, "As long as people believe in their abilities, they act habitually." I guess this is a concern because how do we ever change if this is true.

I have also been working via emails about my thinking. He [person on email] has me concerned that I am expecting too much. Its not that he has said that, but he plays a good "Devil's Advocate." So I am trying to look at myself and why I think that this should all be easier. A part of me knows that I am learning, but I feel like I am lost and don't know where to turn. I do realize that I must be on to something though, but I don't like this feeling. Right now I am confused and frustrated because every time I think I am making some headway he puts another road block in my way.

I now think I have a lot to learn about people.

Discussion: Natasha has realized that she is a clue. Most importantly she is recognizing that this feeling of discomfort that she has is a clue in itself—that is to say that dissonance is an invitation to learn and grow. Her beliefs and what she thinks are clues to understanding her issues with reading and with her new educational role. The statement about needing to learn a lot about people is important because for Natasha it is a clue that she doesn't know how to interact with her group or with the one individual that she discusses from the online community. She had beliefs about what she needed to be successful in her new role and now she is coming to realize for herself what other factors may contribute to her success.

Block 9

Setup: Natasha begins integrating pieces of information (Blocks 3-8).

Natasha's Statement: I am thinking that we need to take the best of phonics based instruction and blend it with the best from whole language based instruction. This thinking has been based on all the reading I have done thus far and my training with my reading department at school. So far, I have had these ideas form in my head on the basis of my study. Reading will still be a concern, but a more personal one.

Discussion: She has created a scenario of what might be needed. She has started to put clues from her inquiry into a cohesive whole. She is still collecting information and searching for clues based on hunches that she has, but a picture is beginning to form.

Block 10

Setup: The following two statements come from Natasha's final progress report. In the final report, Natasha was encouraged to discuss her areas of most significant learning

and the beliefs and assumptions that she has revealed, challenged, validated, and refuted as a result of that learning (Moss, 1998, 2001).

Natasha's Statement: My original assumption of a reading recipe has been soundly refuted. I currently believe that each individual approaches the learning process with a differing readiness level. Due to these differences, educators must craft reading instruction to meet the diverse needs of the individuals in the classroom. The whole language versus phonic debate seems to be a waste of time for educators and the children they serve. Both philosophies contribute wonderful strategies which can be utilized by teachers. Strategies from both approaches must be used to meet the wide range of abilities which teachers face everyday. Some children learn to read almost magically, as advocates of whole language assert. I saw this in my own daughter. But many more children need to have a systematic and explicit phonics instruction during the earliest stages of reading. Most children need to understand that the spoken word is composed of individual sounds which are represented by letters. Each letter represents one or two sounds, some are put together to make unique sounds. Children need to have knowledge about how to decode the print in order to read. They also need to have practice encoding to assist with the reading/writing process. Phonics instruction must be carefully crafted. It cannot be the workbook pages that have been common practice. I believe children must be able to build words and then read decodable text to reinforce the sounds they have just learned or practiced. I have seen this work in classrooms at the schools I service, especially with special education students. While phonics instruction is an important component of reading instruction, is but a part. Children need to practice reading to build fluency and automaticity to the process of learning to read. Unless word recognition becomes automatic, children spend too much time decoding and do not have enough time to concentrate on comprehension.

In order to build comprehension, children need to hear authentic literature. They need to be exposed to the rich vocabulary contained in literature, the well developed characters and the framework of different genres of writing. Since young children are often unable to read independently, they must have frequent read alouds accompanied by meaningful discussion. Without this component of instruction, children may lag behind in comprehension. I believe that listening comprehension is a stepping stone towards independent reading comprehension. This is particularly true for children whom are reading below grade level. They must continue to hear the stories and build comprehension orally until such time as they are able to read on level. Permitting children to hear stories and construct meaning through social interaction promotes growth in the child's knowledge and thinking skills. Children need to understand that they construct the meaning of the text, it is not merely found in the words on the page, something that phonics alone will not accomplish.

I believe that children need to experiment with language in writer's workshop, an important piece of whole language theory. They should be able have permission to "play" with their language skills as they develop them. They need to time to practice composing sentences and stories, using invented spelling, but hopefully that will change as they increase the phonetic awareness. Students need to have time to read and reread text to notice the things accomplished writers do and have the chance to imitate these writers. I believe that a careful blending of the best practices of both theories is the best for all children.

Discussion: Now Natasha has an initial hypothesis. She began with a prior belief about finding a single reading program. This

belief could have developed from authority or a priori beliefs. What is important at this point is her resolution of doubt in the sense that she has examined a large body of information and come to a theory that she can test in the future. She came to this theory by reading information in books and on the World Wide Web and interacting with people in the Teaching as Intentional Learning community. She is currently in the process of testing her new beliefs (i.e., induction) to see if they work out. Specifically, she is using her explanation to predict, that is hypothesis test, a successful reading approach. Once she has gathered information from testing her new hypothesis she may draw a conclusion (deduction) or it may provide her information where she needs to revise her theory and the abductive process would begin again.

Block 11

Setup: What follows is the second statement from Natasha's final report. Unlike the previous statement where she speaks of her learning in the context of reading instruction, in this statement she reveals in her own language what it feels like to wrestle with genuine doubt and notes its power to drive a personal and rigorous personal learning agenda. This quote is not provided to highlight the model but to highlight what genuine doubt experiences "feel" like.

Natasha's Statement: At the end of August, I embarked on a quest unlike any I had ever experienced. Feeling apprehensive, I began to plan my own learning agenda. At first I felt nervous and unsure of how to undertake such a task. Part of me felt elated because I now understand that the nervousness and initial frustration are signs That I will learn something significant. My choice of learning agenda was clear from the beginning dictated by my context as a reading coach. ... It was due to this new context that I felt compelled to learn about reading instruction. ... I do not have a reading specialist certification and felt uncomfortable accepting at face value ... information which was presented to me during my initial training. I felt that I needed to prove for myself and for the teachers whom I would be instructing that these strategies were indeed found in current research. I believe that this focus of study has increased my credibility with the faculties at each school in which I work. It was necessary for me to have a strong sense of self efficacy. Therefore, I chose to learn whatever I could about reading instruction.

Discussion: Clearly, Natasha has realized some things about the workings of her own mind and has become aware of, and even comfortable with, the cognitive dissonance of genuine doubt. She has begun to understand that this feeling of chaos may also be a window of opportunity for learning and reflection.

General Discussion and Implications

The four forms of belief and the ten modes provide a solid theoretical model to examine teacher beliefs and the process by which beliefs change through genuine doubt. The model allows for understanding pre-existing beliefs (knowledge) through tenacity, authority, and a priori and provides a system for analyzing beliefs as they change and the antecedent to that change, genuine doubt. We feel that understanding and using Peircean semiotic models and models developed from Peirce's work can have a strong positive impact on understanding teacher beliefs and, more generally, education. Natasha was a prime example of a person with a pre-existing belief who experienced genuine doubt and resolved that doubt through abductive reasoning. Her experimentation, in Peircean terms, included reading material concerning reading literacy, reading development, interacting with colleagues within Teaching as Intentional

Learning, and reflecting upon her beliefs about reading, but she had not yet begun experimentation in the classrooms. Each of these acted as more and more observations which were then used to develop a hypothesis about reading development and instruction which she is in the process of testing.

Natasha's case is representative of a process that other members of the Teaching as Intentional Learning community have experienced. We have seen time and again that when teachers engage in a learning environment and a learning community that irritates their beliefs, they are driven to resolve doubt. What is critical about the data presented here is that they lend insight into the complex nature of the beliefs that teachers hold, the dynamic complexity of the thinking processes that occur when those beliefs are confronted, and the power of a professional learning community dedicated to systematic and intentional inquiry to heighten awareness and irritation of those beliefs.

In this paper we have argued that genuine doubt and the abductive reasoning process have a significant effect not only on what teachers learn, but most importantly on the beliefs that influence their decisions of practice. As our access to knowledge increases, it is more important than ever before for schools of education to produce educators who can critically examine their beliefs, their knowledge, and their practice.

We have assumed for too long, and we would argue to our disadvantage, that teachers must be told which beliefs are false and which are true. Cunningham (2001) has argued that with increased access to information through modern technology, traditional patterns of deferring decisions to authority figures may be dissolving. It is no longer sufficient to build our schools of education and our professional learning opportunities around the goals of acquiring the skills and techniques of effective teaching.

We have found that a more important outcome of professional learning might be to foster an increased comfort with the state of genuine doubt and the abductive reasoning process that allows teachers to use that discomfort to drive sophisticated and deeply personal learning agendas of their own design. We have also learned that when online communities are formed to irritate beliefs and provide a forum for challenging and examining them, they can influence teachers and teaching in powerful ways.

Natasha came to the Teaching as Intentional Learning community with the belief that there was one best method out there for teaching reading. She also assumed that only disgruntled and ineffective teachers felt apprehensive about working with students' diverse abilities. After using abductive reasoning to resolve her various instances of doubt, she came to recognize the complexity of her concerns. During her inquiry she experienced times when she was lost. Yet, with the support of the community, she kept searching for clues and linking signs. As a result she was able to create the beginnings of a cohesive scenario. More interestingly, at this point in her journey she is just now entering the testing of explanation, the inductive reasoning modes. Clearly significant learning takes time—time to wrestle with uncertainty, to revisit concepts, to compare, to contrast, to hypothesize.

Is it any wonder that Natasha began with the idea that there is one recipe for teaching reading? Many of our schools of education are still built around methods courses that proliferate this notion by teaching techniques and strategies over critical thinking and inquiry.

We would argue that it is to our advantage to equip our nation's educators with not only the most effective instructional methods, but also with the best processes for decision making, collaboration, skepticism, reflexivity, and reasoning so that they can use the real concerns that arise from their practice as starting points for significant learning. In

other words, we must commit to producing teachers who are able to reveal and challenge their beliefs about teaching and learning while engaging in abductive reasoning to resolve genuine doubt.

It is clear that there are extensive opportunities for future research that pursue a thoughtful and critical understanding of how individuals alter their beliefs. We contend, however, that only when the processes of abductive reasoning are considered in both the formation and transformation of those beliefs, will we gain full appreciation for the complexities of those processes and the power that genuine doubt exerts. It is only then that we will be able to create effective learning environments that both lead educators into genuine doubt and allow them the precious luxury of time—time to both gain comfort with the dissonance that genuine doubt brings and time to absorb the learning agendas that it helps to create.

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