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13. PRACTICES AND EMERGING IDENTITIES OF BEGINNING SCIENCE TEACHERS IN ONLINE AND OFFLINE COMMUNITIES OF PRACTICE

A Longitudinal Mixed Methods Study

The inception of this chapter was actually quite personal, as its birth was a direct result of my own long, convoluted, and sometimes painful scholastic journey. Not infrequently, I would find myself pondering, "Of what does the actual evidence of one's authentic self, one's "identity," consist? How can I best perceive and understand this identity? And, what do my conclusions *mean,* what do they tell me about how a person grows and learns to navigate the world?" Evolving through the intellectual and investigational processes these questions sparked, I came to be introduced to, and fascinated by, the various academic concepts used to describe the inevitable relationships that form between one's practices and one's identity—particularly the concepts of Cameron (2001), Holland, Lachicotte, Skinner, and Cain (2001), and Wenger (2008). Through their lenses and those of others, such as (Creswell & Plano Clark, 2007; Yin, 2003), this chapter began and evolved. Over time, it came to explore changes in inquiry-based instructional strategies (IBIS), as well as changes in the teaching practices and identities of beginning secondary science teachers—specifically teachers who participated in an online science-specific *mentoring program* (OSSM), an exploration which came to reveal a great deal about the answers to my beginning questions. Thus, within this chapter, stories related to the practices and identities of 14 beginning science teachers are first introduced quantitatively, and then later, qualitatively. The subsequent quantitative analysis of my findings revealed trends among the group of teachers, which consequently resulted in the purposeful selection of three individuals to serve as appropriately representative cases of each trend. The overall results indicated that there were no significant differences in IBIS scores among the fourteen beginning secondary science teachers over time. Yet, different *shapes* within each trend became clarified from the average scores of IBIS. Three groups of teachers emerged that had either: 1) an increasing use, 2) no change, or 3) a decreasing use of IBIS. The three selected representative cases—called Isabel, Norma, and Deborah—revealed that beginning teachers participated in communities of practice (CoP)s both as *core* members, via online processes, and as *peripheral* members, via offline processes. Additional information revealed by this study included insights as to how the complex pathways that the

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enabling and *disabling* types of participation within the two communities influenced teaching practices as well as the construction of the teacher's identities. This chapter provides knowledge that is based on the cultural and historical perspectives of the subjects and their identities, particularly the ways these perspectives influence both beginning and advanced teacher's developmental processes.

INTRODUCTION

Beginning science teachers face a variety of daunting challenges when implementing inquiry-based teaching while they become members of their teacher communities (Goldrick, Zabala, & Burn, 2013; Luft et al., 2011). As testimonies to these challenges, beginning secondary science teachers who were given materials that supported sound science instruction, continued to implement curricula that were still far from the ideals of contemporary inquiry-based teaching (Roehrig & Luft, 2004). Duschl and Gitomer (1997) attributed this to the fact that teachers tend to use curriculum materials on the basis of practicality—ease of use—rather than choosing them based on how they promote conceptual understanding and scientific reasoning. Demir and Abell's (2010) phenomenographic study also found that beginning science teachers held incomplete views of inquiry teaching, which were highly different from those of science educators. This ultimately undermines teacher effectiveness and student outcomes in a significant, widespread way, which warrants attention.

To make matters more difficult, teacher retention has become an increasingly difficult reality for school systems. Ingersoll (2003) found that approximately 50% of teachers leave within five years of their teaching careers. Yet, Goldrick, Osta, Barlin, and Burn (2013) reported that there is an increasing influx of beginning teachers in today's classrooms. As a result, schools are confronted with the phenomenon of a "revolving door" (Smith & Ingersoll, 2004, p. 706) in terms of their staffing situations. Particularly, a shortage of teachers in the field of science and mathematics is evident when considering the supply of new teachers—when balanced against the losses of teachers—due to retirement, preretirement teacher turnover, and other factors (Ingersoll & Perda, 2009). Ingersoll and Merrill's (2013) recent report indicated that the teaching community is getting greener while becoming less stable. These trends are partially due to the increasing size of the teaching force, as well as the increasing rate of teacher's leaving the profession. Overall, teacher turnover from retirement, per se, is considered a relatively minor factor. Rather, the elements of a school's overall environment, its differences, characteristics, and other conditions are considered as major factors—as they pertain to retention—especially for beginning teachers (Ingersoll & Perda, 2009; Smith & Ingersoll, 2004).

Lack of student achievement in K-12 science education at the international level, and the viability of the STEM—Science, Technology, Engineering, and Mathematics—related job pipeline, as it is likely to play out in the near future, has heavily explored and discussed components, as academicians strive to understand and provide workable rationales that can explain and ameliorate the shortage of qualified science teachers and well-trained graduates (National Science Board [NSB], 2006). One pivotal underlying assumption is that there is a significant relationship between teacher quality and student achievement (Clare & Aschbacher, 2001). Specifically, the meaningful learning of students can be provided and accomplished by highly qualified teachers who exhibit exemplary behaviors and practices guided and sustained by well-informed systematic state policies (Darling-Hammond, 2000).

In an attempt to understand the complex mechanisms or stories related to these multiple phenomena at the conceptual and theoretical level Anderson (2002), classified the barriers and dilemmas experienced by science teachers into three dimensions: technical, political, and cultural. Windschitl's (2002) framework of dilemmas teachers face as they implement constructivist instructions, also provides a valuable lens through which one can explore, in-depth, the processes beginning science teachers negotiate dealing with the complex mixture of conceptual, pedagogical, cultural, and political dilemmas.

At the concrete level, many claim that induction programs help beginning teachers improve their pedagogical expertise (Britton, Paine, Pimm, & Raizen, 2003; Ralph, 2002). Some claim that induction programs can help curtail the attrition rate of these beginning teachers (Strong & St. John, 2001; Villani, 2002). Ingersoll and Smith (2004), whose study focused on different components of induction and mentoring programs, reported that beginning teachers who received various forms of support were less likely to leave teaching. They specifically concluded that comprehensive induction programs—those providing a mentor, collegial group activities, ample resources, and reduced workloads—contributed significantly to teachers' decisions about staying within their teaching careers.

Attention has been given to the creation of induction programs that support content specialists, or secondary teachers. Luft, Roehrig, and Patterson (2003), in a study of beginning teachers in different support systems, concluded that teachers who engage in content-focused induction programs change their practices and beliefs. Ultimately, they concluded that content-focused support systems are essential to the development of the reform-based practices and beliefs of beginning content specialists. There are different types of content-specific induction programs, including those that are online. Online programs have received notable attention, and research indicates that these programs can help content specialists improve their teaching methods and grow in the knowledge they need to teach (Bice, 2005; Zygouris-Coe, Yao, Tao, Hahs-Vaughn, & Baumbach, 2004). Furthermore, online mentoring programs can help beginning teachers use instructional strategies that are important in everyday instruction (Anthony & Kritsonis, 2006; Bang & Luft, 2014).

The purpose of the study was to take an in-depth look at beginning secondary science teacher's changes as they participated in online mentoring communities as a core members, and in offline communities as a peripheral members concurrently. Specifically, changes made by beginning secondary science teachers were explicated by following their inquiry-based instructional strategies (IBIS), teaching practices, and emerging identities over the two years. An important assumption in this study is that practices are inseparable from the processes of constructing identities. It also assumes that practices and identities are located historically and culturally within organizations or structures. Simply put, practices and identities are not arbitrarily built, but tested and modified over time in response to the community. The investigation of teacher changes in practices and emerging identities affords context enriched stories of how newly-hired science teachers make pedagogical decisions as they are faced with multifaceted challenges in different domains. This study provides some clues contributing to the "revolving door" phenomenon. Additionally, it offers science educators' insights about the development of content-based induction programs that provide learning opportunities for beginning science teachers. Lastly, the findings of this study helps educators understand how to strengthen and sustain practices of science teachers that were developed during their pre-service teacher preparation programs. The following explains working definitions of key terms used throughout the study:

- "Inquiry-based instructional strategies (IBIS)," is defined as instructional strategies that science teachers implement in their science classrooms for the purpose of student-centered, hands-on science teaching and learning. Broadly and conceptually guided by the National Science Education Standards (NSES), (National Research Council [NRC], 1996) and bounded by our data collection instruments, we analytically defined 16 items as IBIS for the study. The IBIS items consist within the four sub-categories: 1) types of science lessons, 2) classroom organizations 3) technologies used, and 4) assessments used. Note that not all teaching practices qualify as IBIS in our study.
- "Practice" is understood within a historical and social context, as well as individual and collective levels. We defined practices as any doings that occurred explicitly and implicitly, during the process of one's becoming a member of a community, as well as the ways in which a community welcomes a new member. Especially, practices in our study included online private and offline public spaces. The beginning secondary science teachers made sense of themselves and were related to the world through asynchronous written dialogues, and face-to-face oral interactions. These practices in a community may enable or disable new members striving to become core members (Wenger, 2008). Note that teaching practices are one of many practices within these two communities that shape teachers.
- "Identity" is defined as something flexible and transferable over a lifetime, as one participates in a culturally-coded world. An identity is profoundly shaped through significant activities *that are situated within culture through language* (Gee, 2005; Holland, Lachicotte, Skinner, & Cain, 2001). As for our analytical definition of identity, we borrowed a knowledge base established by Wenger (2008). Therefore, identity consists of identification and negotiability. We argue that the identification aspect of the 14 participants can be summarized as the following: Beginning secondary science teachers from European and Hispanic

ethnic origins who teach at Southwestern states of America with a legitimate teaching license.
- Finally, we defined "emerging identity" as it was investigated within the temporal structure, and it was not considered as a significantly internalized and solidified factor, but rather as a malleable element in the current study (Cameron, 2001).

Research Questions

The questions of interest in the study are:

1. What is the overall pattern of inquiry-based instructional practices (IBIP) of beginning secondary science teachers who participated in an online science-specific mentoring (OSSM) program over two years?
2. How do beginning secondary science teachers in an online science-specific mentoring (OSSM) program change their teaching practices over two years?
3. What are the characteristics of the emerging identities of beginning secondary science teachers? And, *how* do these identities change over time?

THEORETICAL FRAMEWORK

Community of Practice (CoP)

The concept of community of practice (CoP), a social learning system, is drawn in large part from the fields of anthropology and social science theories, especially those of Bourdieu (1986), Vygotsky (1978), and Engeström (2007) who viewed knowledge as a product of cultures whose norms and values are negotiated through dialogues—mediating artifacts such as written and spoken texts—to establish world views (Engeström, 2007; Wenger, 2010). For our concerns, the fundamental domains for which these theories are applicable concern human learning, in general and, more specifically, "the relationship between human begins and their environments." (Vygotsky, 1978, p. 19) By extension, CoP is also concerned with the critical forms of activities or tools as they concern the relationships of "humans to nature." (Vygotsky, 1978, p. 19)

Blended together with the concepts of surviving together and sustaing forward movement, individuals participate in the development of "practices, routines, rituals, artifacts, symbols, conventions, stories, and histories," (Wenger, 2008, p. 6). Therefore, an individual in a CoP organizes his/her life as a series of interactions with the immediate and important members within the CoP with whom they interact. As a result, individuals "develop or preserve a sense of themselves they can live with," (Wenger, 2008, p. 6). CoP assumes that every individual belongs to multiple communities of practice (CoPs), communal entities that change as participating individual lives change—both in formal and informal social settings—regardless of their size, time, place, and space (Wenger, 2008). Finally, belongingness, pervasiveness in teachers' daily lives, as well as informality, can be listed as important elements of a viable CoP.

Practice and Identity

According to Wenger (2008), "practice" is considered as the shared history of learning within the presence of boundary and landscape, while "identity" is considered as a learning process within the spectrum of human experiential trajectories. For instance, when a beginning science teacher enters into a new system or community, he or she begins negotiating ways of becoming—ways to act, think, interact, value, believe, and feel—so as to be successfully assimilated into the community (Dewey, 2008; Gee, 2005). By way of this active participation, shared activities, and interactive experiences, the beginning science teacher inevitably forms a certain texture of beliefs, relationships, attitudes and practices—i.e. forms an emerging new *identity*—that successfully situates the teacher within the new community.

Wenger (2008) delineates "identity" as negotiated experiences within which one's experiences and their social interpretations are in a constantly evolving flux of interactions; the resulting community membership bestowing its members with a community formed identity being which is thus regarded "as a form of competence (p. 153)." Wenger (2008) also claimed that identity is shaped by both participation and non-participation, which are both aligned with their own trajectories of participation. There are two underpinning concepts—peripherality and marginality—which are important to clarify in this regard. "Peripherality" is a process by which non-participating elements of a new comer are activated as "enabling factors of participation" (p. 165). Conversely, "marginality" is a state in which non-participating elements of new comers are activated as "restricted forms of participation" (p. 166). The main sources of participation and non-participation, as defined by Wenger (2008), stem from (a) the ways we locate ourselves within the social landscapes around us, (b) what we care about and what we neglect (c) what we attempt to know and understand, (d) what we choose to ignore, (e) the individuals with whom we seek connections and whom we avoid, (f) how we engage and direct our energies, and finally (g) how we attempt to steer our trajectories.

Wenger (2008) also defined identity as a *process* of belonging to communities of practice. During this process, an individual may engage in at least three modes of belonging: engagement, imagination, and alignment. As a source of identity, engagement is "an active involvement in mutual processes of negotiation of meaning (Wenger, 2008, p. 173), which is restricted by the physical limitations of time and space. The second mode, imagination, is quite the opposite in that it is about "a process of expanding our selves by transcending time and space and creating new images of the world and our selves (Wenger, 2008, p. 176)." Although this mode involves stereotypes, Wenger assured that this mode can "make a big difference [in] our experiences of identity (p. 176)." The third mode, alignment is about bridging time and space to locate ourselves in the social landscape and therefore, "play our part" (p. 179).

Wenger (2008) claims that identity forms as the result of a dual process: "identification and negotiability." The former provides "experiences and materials for building identities through an investment of the self, in relations of association and differentiation (p. 188)." The latter "determines the degree to which we have control over the meanings in which we are invested (p. 188)." Importantly, this study explored the dual aspects of identities based on how participants engage, image, and align themselves in order to become inquiry-based teachers in the online mentoring situation.

This study was built based on the knowledge established in CoPs in order to understand the phenomenon of beginning secondary science teachers' changes. Especially, a CoP affords a theoretical map through which the journeys that this special group of teachers made (Sinclair, 2007). The core knowledge upon which the study is based is adopted from the CoP, i.e. it is the set of processes through which new members of a CoP both successfully and unsuccessfully become core members. All of this takes place while the new members are constantly interacting with their new environments through interpersonal relations, tools, or any other helpful means available for them. Therefore, these new members can be observed to develop a sense of their identities, *within the boundaries of their communities*, while constantly negotiating their personal trajectories towards the future. Figure 13.1 describes how the current study is situated within this core knowledge, as it has been adopted from the CoP.

The approach adopted in this study—coupling practices and emerging identities through written and spoken utterances as mediating artifacts—is important in the sense that some consider the duality of practice vs. identity as indispensible in understanding human development (Holland & Lave, 2001; Wenger, 2008). For instance, Cameron (2001) considers the use of language as an integral part of social practices, and claims that "Language-using is an act of identity" (p. 170); therefore defining identity as "something you do" (p. 174). In the simplest terms, it is in doing X, Y, and Z that one *becomes* A, B, and C (Cameron, 2001). A good example of this concept of practice and identity can be found in the study done by Skinner and Holland (1996). In their seven-year study with Naudadan school students, they found that students constructed identities as a result of practicing talks/songs/and dialogues about their lives. They also found that orchestrating multiple perspectives and voices from multiple sites (e.g., home, school, and community) helped them form their understanding of themselves within their worlds. Holland and Lave's (2001) concepts of "identities-in-practice" (p. 3), as well as the cultural production of identities (p. 5), also represent the inseparable nature of practices and identities. The baseline assumption behind these concepts is that there are "relations between subjects' intimate self-making and their participation in contentious local practice." (Holland & Lave, 2001, p. 5).

Closely associated with the concepts of practices and identities is an analytical construct that consists of two different types of mediating artifacts—both written and spoken discourses. According to Gee (2005), language is the essential building

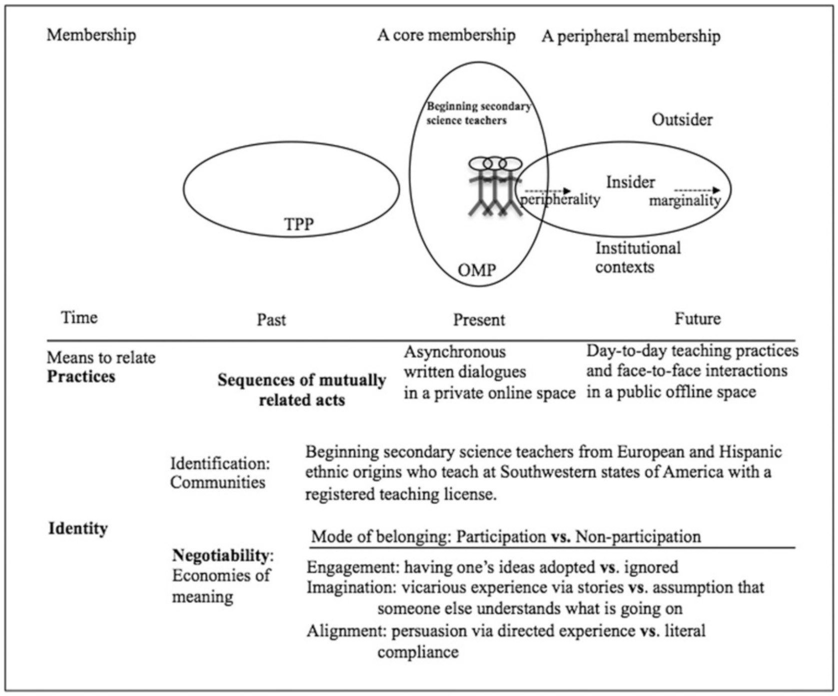

Figure 13.1. The design of the study within the core knowledge based from CoP (Wenger, 2008)

material of activities, identities, relationships, politics, connections, sign systems, and knowledge. Specifically, language is used "on site to enact specific social activities and social identities" (Gee, 2005). Moreover, Cameron (2001) claims that people pronounce their identities through language-in-use, during their participation within social practices. An example can be found in Fairclough's (2003) textual analysis, where modality, evaluation, and personal preferences demonstrate the analytical link between styles and identities.

RELATED LITERATURE

Inquiry-Based Practices

Central to the discussion and studies of science as inquiry, has been the *National Science Education Standards* [NSES], (National Research Council [NRC], 1996). Since the release of this document, researchers have contemplated the various methods of inquiry instruction, as well as the *enactment* of inquiry within the classroom. In studies about the use of inquiry in the classroom, many researchers have noted the significantly positive impact of inquiry instruction upon students (e.g., Chatterjee, Williamson, McCann, & Peck, 2009; van Rens, van der Schee, & Pilot, 2009). For instance, van Rens et al. (2009), observed significantly positive student learning in the area of molecular diffusion, as students engaged in inquiry-based environments and activities. The students who participated in this inquiry format had opportunities to brainstorm ideas, observe demonstrations, participate in guided experiments, and engage in meaningful and productive group discussions. Chatterjee et al. (2009) concur with this evaluation. Their survey results, derived from approximately 700 students working in inquiry-based laboratories, indicates that students show positive attitudes towards guided-inquiry laboratories, and believe they learn more naturally and effectively with guided-inquiry laboratories.

Among all teachers, newly educated science teachers actually have the most potential in terms of enacting inquiry instruction, as they have the most current training and knowledge of inquiry. However, they admittedly have limited *experience* in using inquiry in the classroom. By contrast, more experienced, established teachers tend to have deeply entrenched teaching philosophies and practices that could actually run *counter* to inquiry based practices in some environments. Some teachers, in fact, may even be resistant to inquiry practices, or find them difficult to learn. When new teachers interact with established teachers, even the school administration, there may be problems—as there may be limited support for inquiry, or they may not have access to a robust induction support system that focuses on inquiry instruction (Roehrig & Luft, 2004, 2006; Luft, 2009; Luehmann, 2007).

Mentoring Programs for Beginning Teachers

Historically, mentors have demonstrated profound help for beginners along a wide spectrum of teaching components and venues. Specific to our study, Luft et al. (2011) stated that e-mentoring programs helped new science teachers build their inquiry practices and knowledge over time. Science-specific induction programs also hold promise for helping new science teachers transcend the resistance to change that may manifest as they begin implementing contemporary inquiry practices (Luft et al., 2011). However, to fully understand science-specific, electronic teacher/mentor relationships, it is important to examine existing studies and conclusions regarding the general mechanisms and effectiveness of mentorship for newer teachers.

After qualitatively analyzing 29 teacher mentor and mentee relationships, Abell, Dillon, Hopkins, McInerney, and O'Brien (1995) found that new teachers needed someone to "lean on," and that establishing respect and trust were critical factors for successful mentor-mentee relationships. As a result, mentees and mentors took part in interactions that not only supported teaching and learning, but also created personal, confidential, and immediate discussions and relationships.

Furthermore, Abell et al. (1995) identified different types of mentor roles in experienced and new teachers. For instance, mentors self-described, and were described by others, as parent figures that protected new teachers, while at once helping them become independent. Mentors were also described as "trouble-shooters," functioning as colleagues, where *both* mentees and mentors brought new ideas and learned from each other to solve problems. Finally, mentors were described as "scaffolders" who shared their pedagogical content knowledge while providing critical underlying support on many other levels. Frazier and Sterling (2009) also emphasized the critical roles of mentors in providing practical and sustained support systems for new teachers. As role models with empathetic ears, mentors are expected to bring new teachers to their science classrooms, help them organize materials, and guide them to practice different types of assessments. In this way, mentors and mentees form strong professional collegiality, which helps them not only solidify their mentor-mentee relationships, but ultimately provides the cornerstones and building blocks for entire communities of practices.

Identity in New Teachers

The identities of new teachers develop in a variety of ways, and their identities can take on different meanings (e.g., Britzman, 1991; Volkman & Anderson, 1998). For instance, Varelas, House, and Wenzel (2005) explored identity development among beginning science teachers after participating in a ten-week summer science apprenticeship at a science lab. As science *teachers*, they crafted identities that valued facts, knowledge, sequential experiences, and regularly established times and settings for learning. By contrast, as science *workers*, their identity formation included notions that science was "messy," "floundering," exploratory, dialectic, and laden with risks. Notably, in spite of this disparity, the beginning teachers were able to develop and integrate both identities successfully.

As beginning science teachers build their identities, other challenges and mediating forces come into play. The challenges that teachers can face have been studied and described by researchers, and include traditional and passive teaching environments, a lack of knowledge about ways to teach that align with the *NSES* (NRC, 1996), and/or conflicting practical and theoretical positions (e.g., Luehmann, 2007; Windschitl, 2002). A potential solution to these challenges resides in qualified mentors, or "significant narrators" (Sfard & Prusak, 2005), who can help new teachers develop reform-minded identities while remaining in line with institutional expectations. In order to effectively assist the new teacher, the mentor or narrator should be knowledgeable about reformed-based instruction, and respected by the new teacher. Together, over an extended period of time, the new teacher and mentor/narrator should collaboratively engage in practices that build progressive, trusting, and effective identities, with tools like post-teaching debriefing sessions and portfolio discussions (Luehmann, 2007). Individually, new teachers may keep web logs (blogs), present and attend professional meetings, use emerging social media intelligently to expand their associate bases, and reflect purposefully on their practices both on and off line (Luehmann, 2007).

To summarize, science as inquiry is established and endorsed as the most authentic method of teaching science; yet, this practice can present difficulties even for experienced and knowledgeable teachers. But, new teachers have a good chance at implementing inquiry if they participate in well-designed, science-specific, *online mentoring programs.* Early research indicates that these types of programs can impact a teacher in positive ways, however, little is known about *how* online mentoring programs impact the practices of beginning science teachers. The identity a new teacher holds may offer insight into the ways an e-mentoring program impacts his/her development into a mature, seasoned professional. Furthermore, the identity that one constructs in this more progressive manner becomes distinctly discernible, and can reveal, or at least give significant clues to practices that are used within the classroom.

METHODS

Research Design

This study adopted a mixed methods, especially "sequential approach" design upon a time order decision (Creswell & Plano Clark, 2007; Tashakkori & Teddlie, 2003). Tashakkori and Teddlie (2003) claims that this process provides an understanding of the context or setting with qualitative methods, and creates a less biased interpretation than that presented by solely quantitative methods. Additional rationale came from the fact that this approach allowed for the collection and analyzing of data in a more comprehensive way than that allowed by a single method approach. With it the questions involved can be examined more thoroughly. Finally, it offers a form of triangulation that enhances validity in that it measures the same phenomenon from different angles or positions; therefore, offering a multi-faceted/multi-dimensional way of exploration (Mason, 1996).

Specifically, once the data were collected through qualitative methods. We conducted initial qualitative data analysis for multiple purposes (e.g., coding to secure IBP scores of 14 teachers, quantification of qualitative data). Subsequently, a quantitative approach, Hierarchical Linear Modeling (HLM), was used in order to determine the overall pattern of the beginning secondary science teachers' inquiry-based practices (IBP). As a result, three cases were selected in order to explore the two-year changes in teaching practices and identities of beginning secondary science teachers. To explore more of these findings, a qualitative approach, that of the "case study," was used to illuminate the stories about teachers' changes in their teaching practices through the lens of identity constructions (See Figure 13.2).

Context: The Online Science-Specific Mentoring Program (OSSM)

The online science-specific mentoring (OSSM) program is part of a large five-year induction study conducted in the Southern and Midwestern regions of America.

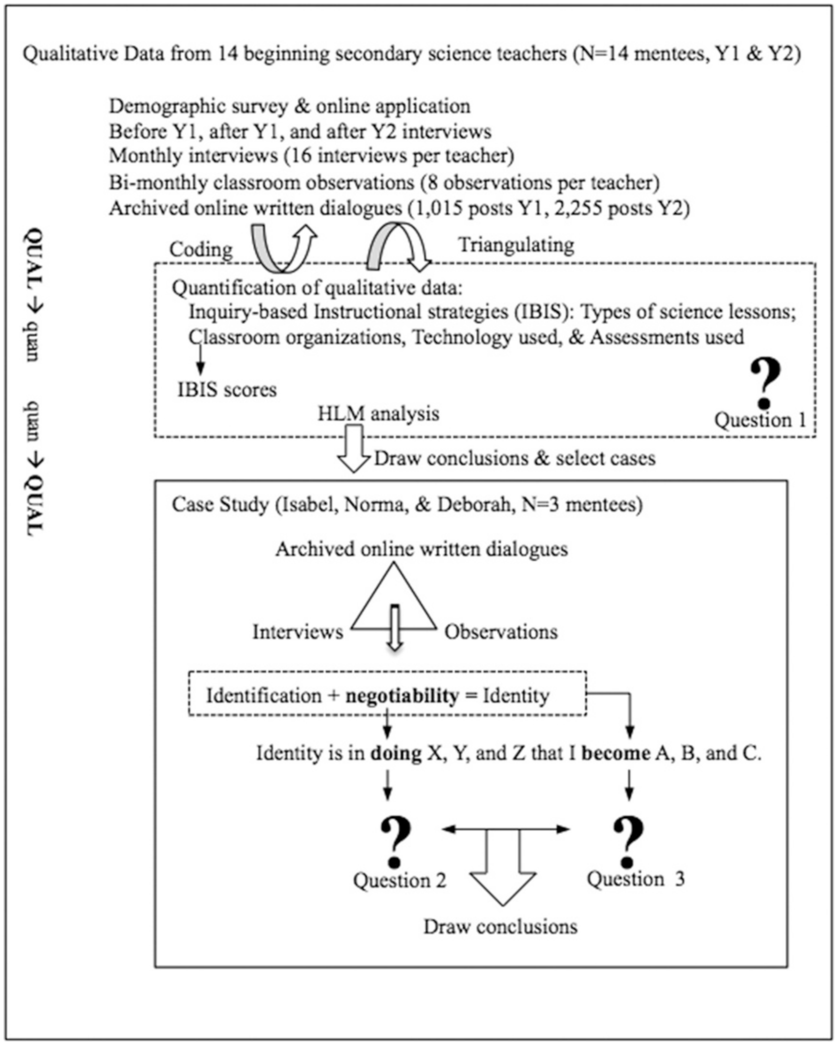

Figure 13.2. Mixed methods design of the study

Online data used for the study was retrieved from the electronic–Mentoring for Student Success Program (eMSS program), which was stored on a WebCT platform (Jaffe, Swanson, & Wheeler, 2006). The eMSS program began in 2002 in the United States, and has expanded from two states to sixteen states within four years.

All participants are encouraged to post at least three or four times per week, regarding any issues related to science teaching, in any of these strands. During the two years of this study, the beginning secondary science teachers and their mentors participated in online training activities before getting started in the mentoring program. On a weekly basis, we monitored the activities of participants, and inactive participants were encouraged to engage in the online mentoring process via emails and phone reminders. The mentee and mentor participants in the OSSM also had an opportunity to meet face-to-face at a state science conference where we set up a booth to host an informal lunch meeting.

Finally, the nature of the archived written dialogue's data between mentees and their online mentors were that of asynchronous threaded discussions, where interactions were made through texts—as a tool to cognitively, socially, and culturally relate to one another. Asynchronicity in our study meant that there were lags between mentee and mentor interactions; thus, there were advantages for reflection of topics and flexibility of time. van Dijk's (2006) scholarship on the concept of discourse was also layered into our study in that text-based interactions, similar to oral-based interactions, are also deemed "sequences of mutually related acts" (p. 3). Finally, our archived written dialogues data also had features of convential ways of sharing a contextual frame, turn-taking, paralinguistic cues, and reflexivity of the reality (Gee, 2005; Werry, 1996).

Participants

The mentees. 11 female and 3 male beginning science teachers taught at Southwestern state institutions as full time science teachers, who held either a B.S. (50%) and or an M.S./M.Ed. (50%) degree. The majority of the beginning teachers took at least 1 or 2 science method's courses; yet none of them took history and/or philosophy of science courses. Most of them taught at urban public schools with an average of 1350 students. These schools had a traditional 50 minute-schedule with an average class size of 25 students. 64.29% of the science teachers taught out of their specifically-disciplined content area. Six teachers taught at schools that had less than 25% Caucasian students. As for the new teacher support system, most of the teachers had informal support either from teachers-next-door or, another teacher outside their schools, since none of the teachers had formal support from their schools. Most of them, however, had either mandated or optional professional development opportunities throughout the year. None of them had full or part-time aides to help prepare them for instruction. Six teachers and three teachers reported that they had no formal curricula provided, or appropriate supplies provided for their science instruction, respectively.

The online mentors. Nine female and five male science teachers were recruited and then matched with beginning science teachers to be online mentors. The average science teaching experiences of the mentors was 19 years, the full range being from 7 to 35 years. All the mentors had formal training in more than one science subject, and had some experience mentoring, training, and/or supervising new science teachers at school, district, and university settings. Finally, the majority of the mentors in the study held a leadership position either within at their schools or districts.

Selection of three cases. As suggested by Yin (2003) and Eisenhardt (1989), we based the case selection on two factors: feasibility and sample variation. In terms of feasibility, it was essential that adequate data was available. Therefore, three cases were selected among the 14 pairs who were active and had sufficient and consistent data, while they participated in the content-focused online mentoring program for the full two-year duration. Active involvement was evaluated based on a rubric created by the eMSS program (Jaffe, Swanson, & Wheeler, 2006). This rubric included the following criteria: 1) frequency of interactions per week, 2) number of postings read, 3) quality of postings, 4) evidence of trusting relationships, 5) connections to content. 6) skills of mentors, 7) mentee posts, and (8) mentor responses. Also considered when selecting cases, were the differences pertaining to the use of inquiry practices. The cases were selected based on the results of the quantitative analysis. Three categories were used to differentiate the cases: Isabel's case (code number 11), for increasing the use of inquiry practices. Norma's case (code number 1), for no change in inquiry practices. And Deborah's case (code number 5) for decreasing the use of inquiry practices. "Increasing use" was defined as a teacher being able to make an increase in the IBP scores over time. "No change" was defined as a teacher neither being able to increase or decreased the use of inquiry practices. "Decreasing use" was defined as a teacher decreasing his or her IBP scores over time.

Selected three cases. The selected three cases represented the trends of longitudinal growth in inquiry-based practices within each group. Isabel was chosen to represent the "increasing use of inquiry-based practices" group. Isabel held a life science major and had master's degree in education. She had 12–16 weeks of student teaching and took a science methods course before starting her career as science teacher. She taught integrated science at a middle school in an urban setting school that ran a traditional schedule (45–60 minute classes each day). Although she voluntarily changed schools at the end of the first year, she was in the same district for two years. The student population at her school consisted primarily of European-Americans (68%), only 6% of the population was classified as English Language Learners. The only formal induction program for Isabel was the OSSM program, as there was no induction program available at her school. Furthermore, no specific science curriculum—other than the standards—was provided and no new supplies for teaching were provided.

Isabel had two online mentors—Karen (year one), and Michael (year two). Karen, her first mentor, was a 7th grade science teacher when she joined the OSSM program. She had been teaching for 19 years, and had 27 credits in life, physical and Earth science. Even with her background, she felt most comfortable with teaching the life and physical sciences. Over the years, she had functioned as a mentor teacher, a classroom teacher for student teachers, ran science workshops for elementary teachers. Michael, Isabel's second year mentor, had just submitted his National Board Certification portfolio in chemistry and was awaiting the results. Over the years, he developed several courses including a non-academic environmental science class and an environmental chemistry course for college level students. He took a number of Advanced Placement (AP) workshops, which enhanced his teaching of AP chemistry, AP environmental science, and International Baccalaureate chemistry. He had a Bachelors degree in biology, with specialization in botany and a minor in chemistry, and had achieved an additional Masters degree in plant physiology. His teaching career began in 1983, when he received an emergency credentials due to the fact that the local district urgently needed science teachers. Since that time, he had accumulated a wide range of experiences as a teacher for 16 years, and obtained his teaching certificate by taking educational coursework.

The second case, Norma's case, was selected because she made no changes in her inquiry-based science practices over two years. Her background was in ecology and evolutionary biology, specifically in population genetics and speciation, with special interests in rodents, snakes, and sperm competition. She received her Masters in Education through a one-year program, which provided an entire year of student teaching. When she joined the OSSM program, she was teaching four sections of advanced biology and one section of honors biology at a private high school. In addition to teaching, she coached girl's cross-country at her school. Norma was contracted as a full-time life science teacher during year one, and as an Earth science teacher during year two. Her school varied the schedules during the week, which resulted in both traditional and blocked schedules.

Norma's two mentors, Gina and Cathy, were both retired biology teachers with more than 30 years of teaching experience individually. Gina, who was Norma's online mentor during the first year, co-authored and was director of a five-year, five-million dollar National Science Foundation grant for systemic reform of science education in her district's K-8 schools. In this project, she facilitated the design and implementation of a standards-based, science professional development program for over 1,500 teachers and administrators. Cathy, who was Norma's online mentor during the second year, served as the department chair at her last school. She also supervised numerous student teachers and recruited and coached new teachers in her science department.

The third case selected involved mentors and a mentee in the OSSM program, but included the "decreasing use" of inquiry-based science practices over the two years. Deborah and her online mentors were selected as the representative cases in this category. Deborah had a Bachelors degree in chemistry, but went to a local college in order to finish her teaching requirements. She took most of her education classes online and student taught for eight weeks. During her first year, she was assigned to teach three freshman physics courses, and an honors section of physics. This changed in her second year, when she was assigned three classes of freshman physics and two chemistry classes. Her school has a traditional schedule and most of her students are Caucasian.

Deborah's two online mentors, Lucy and Louisa, each have seven years of teaching experience. Lucy had prior mentoring experience during the previous year in her school district, when she served as a mentor for a first-year physics teacher. At the time of the study, she taught high school physics and astronomy. Louisa, who was Deborah's second year mentor, taught eighth grade science (general science), and had experience teaching sixth through 11th grade in mathematics and science areas.

Data Sources

Six data sources were used for the study. These included: a demographic survey, mentor online applications, semi-structured monthly and yearly interviews, classroom observations, and two years of online written discourse in the form of asynchronous threaded posts. The demographic survey and mentor online applications were collected at the beginning of the study in order to capture the background of the participants. A total of 14 demographic surveys were collected. The surveys were reviewed by graduate research assistants and coded accordingly. The categorical codes included information about teachers and their schools. For instance, teachers were asked to comment on the length of their student teaching, their school type, the locations of their schools, and other such topics. Codes were assigned with a non-value number to differentiate among possible categories for each question. For example, a female teacher was coded as 1, while a male teacher would be coded as 2.

Monthly interviews were collected during the academic year by using the Weekly Update Coding Sheet, which was based on the work of Lawrenz, Huffman, Appeldoorn, and Sun (2002). This is a semi-structured instrument in which participants are asked to answer open-ended questions and report on their instruction for five days during one month. Six graduate student assistants and an expert science educator collected this data. The interview sessions were audio-recorded and notes were taken by the interviewers as the mentees discussed their practices. The duration of the interviews lasted from 25 minutes to 60 minutes. A total of 220 interviews were collected for this study. The interviews collected from the fourteen science teachers were equivalent to 80 days of science instruction per teacher.

After the interview, the interviewer was responsible for coding the interview, and saving the audio-recording. Coding the interview was done by placing check-marks on a "Weekly Update Coding Sheet" based on the descriptions made by the mentees. The weekly update coding sheet was divided into four sections: lesson components, classroom organization, materials/technology, and assessment sections. The lesson component section has 28 possible items for illustrating different types of lessons, such as student research projects or teacher-led class discussions. The classroom organization section contains 11 possible items for describing ways that students can be organized and the origins of their lessons. In terms of student organization, topics such as individual or cooperative learning would be coded, while the source of the lesson plan would be noted; for example, as cooperating-teacher, teacher-next-door, or textbook. The materials/technology section had seven possible items for describing what kinds of materials/technology were used during the lessons. Items like computer-internet or common laboratory items could be noted in this section. Finally, the assessment section had 14 possible items for identifying the types of assessments used during the lessons. This section contained topics such as quizzes or short answer test questions. Once coded, an undergraduate student entered data in an Excel spreadsheet. From these items, 16 were identified as inquiry-based practices (IBP) in lesson planning, classroom organization, technology used, and assessments based on the *NSES* teaching standards (NRC, 1996).

Classroom observations were collected throughout the year by six research assistants and an expert researcher. The observation instrument protocol was a combination of Lawrenz et al.'s (2002) Components of *The Collaborations for Excellence in Teacher Preparation* core evaluation classroom observation (CETP-COP) and the *Oregon Teacher Observation Protocol* (O-TOP) (Wainwright, Flick, Morrell, & Schepige, 2004). The CETP-COP has a high internal consistency with a coefficient alpha of 0.9 (Appeldoorn, 2004). During the CETP-COP, assessments were made every 5 minutes and they included: the classroom organizations (e.g., individual work or group work), the activity (e.g., lecture, directions, activity), the level of student engagement (e.g., highly engaged), and the intellectual orientation of the activity (e.g., knowledge, application). The duration of observations ranged from 60 minutes to 110 minutes. This was due to the different schedules of schools, which dictated the length of the classes.

As for the online written data collection, we monitored the participants' dialogues from the OSSM program. Online dialogues were monitored during the academic year and inactive participants were solicited to interact with their pairs via emails and phone calls. The data that was saved included the threaded discussions that showed who initiated the dialogue, the subject of each post, and the dates and time that the posts were uploaded. This resulted in a total of 1,015 posts that were made among 25 pairs in year one, and 2,255 posts among 20 pairs in year two. The duration of data collection was two academic years. Sixteen interviews per teacher were conducted each month over the phone and audio recorded. Each teacher was observed four times during his or her first and second year—a total of eight times. A different number of graduate student researchers and an expert science educator assisted in the data collection procedure throughout the two years. Finally, the participants, principals, and districts involved in the study were informed about the nature of the study. Beginning teachers and the mentors received a stipend for their work associated with the study. All active researchers were trained and certified before conducting the research. Pseudonyms were used in a way that the participants' identities and schools would never be detected and their anonymity fully protected per protocol.

Data Analysis

Analysis of quantitative data (IBIS scores). Hierarchical Linear Modeling (HLM) is known as a powerful tool for analyzing individual changes over time. The main premise of HLM is that individual changes are not understood as either incremental, or comparisons between "pre" and "post." Instead, HLM captures changes on a continuous scale where multiple waves of data are compared over time (Willett, Singer, & Martin, 1998). According to Singer and Willett (2003), longitudinal data can be used in a nested structure, such as a group of beginning teachers within an OSSM program. In order to conduct an initial analysis to see the overall pattern of our data set and select cases, sixteen data points were used that consisted of IBIS scores, which consisted of the totaled scores from the monthly interviews. After calculating all the IBIS scores of 14 teachers, the IBIS scores of each teacher were entered in Excel spreadsheet. Each of these scores was referred to as a "wave." These sixteen waves of data represent two years of data, or 16 full months of instruction. Teacher's changes were measured by plotting row scores of IBIS on the vertical axis, versus the progression of their teaching careers (e.g., one month, two month etc.).

Analysis of qualitative data. This study adopted time-ordered displays as a strategy of describing the encoded qualitative data. According to Miles and Huberman (1994), time-ordered display is "a second major family of descriptive displays. This strategy orders data by time and sequence, preserving the historical chronological flow and permitting a good look at what led to what, and when," (p. 110). In this study, practices and identities of three beginning science teachers were displayed through events as they participated in an OSSM program.

A traditional left-to-right matrix was created each semester, in order to follow the different events of the three teachers who comprised the cases. Only critical events, which were coded, were presented on the matrix. For instance, offline data (surveys, interviews, and observations), and online data (written dialogues), were analyzed based on the "doings" of beginning science teachers per semester. Specifically, offline data was encoded based on the events surrounding the science instruction of the beginning secondary science teachers within a semester. The online data was also organized by semesters, and data not related to practices were eliminated.

After the elimination of unrelated data, sentences that described and hinted at events surrounding instruction were selected and grouped. The coding of data was accomplished through verbs used by each teacher, as these verbs captured the salient intent of the action involved (Bodgan & Biklen, 2007). These verbs were marked when they indicated "doings" within the engagement, imagination, and alignment mode of belonging (Wenger, 2008). For instance, when a mentee wrote, "I follow all the lesson plans from the teacher next door," the verb "follow" was selected as the main representation of practices as related to the teacher's identity. Then, this "verb" was cross-checked with our interview and observational data. Only "verbs" that were actually enacted consistently during each semester in the classroom practices were considered as possible codes for emerging identities.

FINDINGS

IBIS Scores

In order to answer the first question, HLM was used to model the beginning secondary science teacher's changes in inquiry-based instructional strategies (IBIS), both collectively and individually. The starting points—were statistically significant t (1, 13) = 7.89, $p < 0.01$; however, the slopes, the rate of the beginning secondary science teachers' changes—were not significant t (1, 13) = 0.20, p = 0.85. A significant starting point indicates that the samples varied significantly from the beginning of the study. However, the slopes revealed that there were no significant changes within each participant over the course of the study. When the IBIS scores were plotted by all participants for 16 data waves, it was evident that beginning secondary science teachers' inquiry-based instructional strategies were low, overall. Yet, noticeable trends became apparent (See Figure 13.3).

As a guide, the combined linear growth model of the participants showed that three different groups formed within the overall group who participated in the OSSM program: Group 1 *increased* their use of inquiry-based instructional strategies, Group 2 made *no changes* in their use of inquiry-based instructional strategies and finally, Group 3 *decreased* their use of inquiry-based instructional strategies.

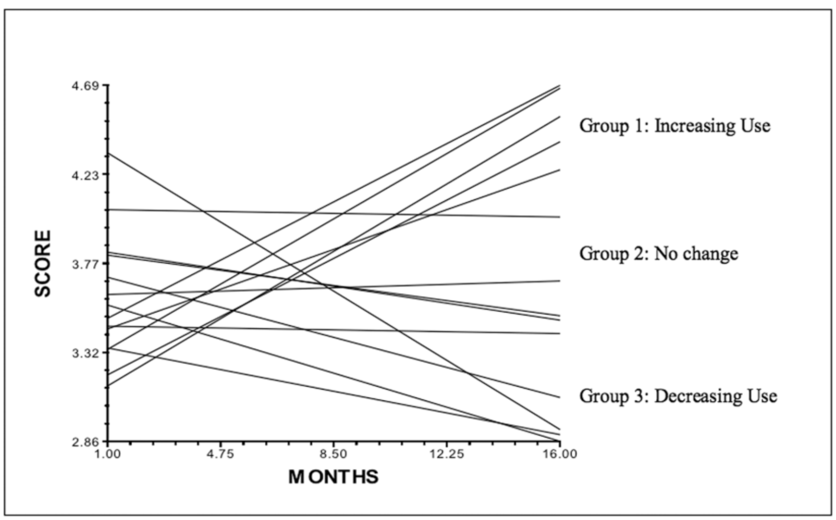

Figure 13.3. The participants' inquiry-based instructional strategies (IBIS) change over time

Isabel's Case: Changes in Isabel's Teaching Practices

Year one: September – December. Isabel uses an opening activity for every single lesson, then gives directions pertaining to the lesson. After the activity, students are assigned appropriate reading materials or worksheets, which they work on individually. At first, most of her lessons were adapted from her colleagues, while occasionally she found new lessons on the Internet. Towards the end of the first quarter, however, Isabel acquired most of her lessons from the Internet. Her lessons consisted of guided-inquiry activities and she utilized few assessments.

Year one: January – May. Her science practices during this time are a mixture of verification labs, guided inquiries, and worksheets. She is still using an opening activity, but is trying to incorporate smaller group discussions. She is also starting to use more assessments in her classes, such as rubrics, essays, and asking her students informal questions.

Year two: September – December. Isabel is spending large amounts of time reviewing activities, and tends to use directed and guided inquiries. Most of her lessons are adopted from the previous year; but she incorporates reading and worksheet activities as well. She still prefers small group work for most of her lessons—using rubrics for student assessments. Traditional assessment strategies and short answer quizzes are starting to appear, while at this time there is a decrease in her use of alternative assessment strategies.

Year two: January – May. Isabel is using more videos, and returns to using more alternative assessments. Most of her lessons are adopted from the previous year, but are revised and updated. In her classes, she is beginning to enjoy and appreciate geology, even though her background is in biology. During this period, she is not attending any professional development programs, nor is she participating in the e-mentoring program. She defends her lack of participation in these venues by saying she does not have time, and that, "They just don't give me the lessons I need." The time-ordered matrix, from which this case is written and the other cases, is found in Table 13.1.

Emerging Identities of Isabel

Watchful-follower. "I am just reading and doing notes from the textbook… the program I went through suggests inquiry." When Isabel began teaching, she followed the lessons of her mentor. This was largely due to a lack of time, and a lack of content knowledge. She was not satisfied with what she was given, because it was not inquiry-based. As a result, throughout the year, she constantly reminds herself not to rely on the textbook alone. The online dialogue between Isabel and her e-mentor, Karen, demonstrates not atypical tension between a newcomer and an expert. When Isabel criticizes the quality of lesson plans, she receives from the experienced teacher at her school. Karen tries to defend the common practices of the community by telling Isabel that most schools have their own textbook or curriculum to follow, and inquiry-based practices can be compromised in order to get good results on standardized tests. Also, Karen encourages Isabel to be more cautious about the philosophy of inquiry-based practices. Even if Isabel constantly displays confusion between how she has to teach and how she wants to teach science at her school, Karen puts an emphasis on "just going with the flow." Karen is trying to keep Isabel from being excessively stressed during her first year.

> Message no. 235 Posted by Isabel: I feel a thousand times better about week 4's lesson plan. We were doing this boring bookwork...reading right out of the book and going over important notes. I was just taught differently. I think that those types of activities should come after some sort of engaging activities first and exploring activities…

Seeker. *"Do you have anything for Space Science?"* During the second semester, as a first year teacher, Isabel reaches a point where she has used up all of the materials given to her by the other teacher. She now seems to have no idea in terms of what to teach, nor does she seem to have sufficient content knowledge. She thus turns to the Internet and other resources in an attempt to find new lessons. Via online dialogues, Isabel turns to her e-mentor seeking new science lessons. When she receives packets from Karen, Isabel successfully incorporates some of the ideas contained within, into her lessons.

Collaborator (offline) and backseat driver (online). *"I think there is also one underlying problem. I don't think the instructional coach really does his job. I will further explain."* Isabel wants to be a team member at the beginning of the second year. She does this by voluntarily mentoring another teacher, and by taking on additional responsibilities at her school. Although Isabel requests more support from her instructional coach, she emphasizes the importance of teamwork, and tries to understand the lack of support from her instructional coach by recognizing the complexity of his job. Isabel, however, displays a quite different identity when she interacts with her e-mentor via online discussions. At school, she represents herself as a collaborator, but online she displays herself as a "backseat driver," where she intensively criticizes her instructional coach—on his lack of knowledge and skills teaching science and his unprofessionalism. Her online mentor becomes a passive listener in order to ease the situation, and becomes an empathetic ear.

Junior leader (offline). At the end of the second year, Isabel now feels she is becoming a junior leader. Several other beginning science teachers are asking her questions, and she shares her lessons with them. Isabel also takes on additional school responsibilities, and she actively focuses on modifying previous lessons.

Norma's Case: Changes in Norma's Teaching Practices

Year one: September – December. In terms of science practice, Norma states, "I am really trying to integrate inquiry, but I find it really hard." Most of the time, Norma starts her lessons with an opening activity, and then lectures or has the students complete a verification lab. She lets students work together, and enjoys and prefers group activities in class. She typically uses short answer quizzes during a unit, and multiple-choice tests at the end of a unit, to assess student knowledge/progress.

Year one: January – May. Norma's science practices continue with the same pattern that she had in the fall. She uses opening activities for most of her lessons, and incorporates worksheets and verification labs for the main activity. However, she does try a directed inquiry investigation in the spring. She likes this format of investigation, but is not sure when she will use it again. The traditional nature of her instruction is evident in the notes of one observer:

> I am sitting in this class again, and she is lecturing. She has a very detailed lecture, and it has lots of information. The students are taking notes and they occasionally ask questions. Norma is happy to answer the student's questions, and then moves on to the next topic. (Observational note, February)

Year two: September – December. Her instruction is again much the same, which consists of lecturing and verification laboratories. Things are easy, and Norma wants to keep it this way. Everything this year is similar to last year. She is still getting help from the teachers at her school, and she is still active in the OSSM program.

Year two: January – May. Her instruction is essentially the same as before, as is her use of assessment instruments. She is also communicating with her e-mentor, but this communication is mostly about her instruction. In response to apparently limited interactions with her colleagues, she is turning more and more to her Internet connections for knowledge and inspiration.

Emerging Identities of Norma

Follower (offline) and Watchful follower (online). "I still haven't decided how I feel about videos." Even though Norma utilizes every kind of lesson from the teacher next door, she has concerns about using videos, per se, in class when Rosy, the teacher next door, lends them to her. She is worried that the videos will be

Table 13.1. Time-Ordered matrix: Summary of each case

Year	*Y1*		*Y2*	
Marked semester	*First semester*	*Second semester*	*First semester*	*Second semester*
Increasing Use in IBIS Scores: Summary of Isabel's Case				
Teaching practices	Reading & worksheets. Small group work. Limited assessment. Guided inquiry. Cooperative work. Rubric.	Verification labs & Worksheets. Small group work. Rubrics, essays, & informal questionings.	Reviewing, directed, & guided inquiries. Small group work. Short answer quiz.	Videos. Cooperative grouping. Computer software. Informal questioning.
Emerging identities	Watchful-follower	Seeker	Collaborator (offline) Backseat driver (online)	Junior-leader (offline)
No Change in IBIS Scores: Summary of Norma's Case				
Teaching practices	Opening/closure activities. Lectures & verification labs. Individual work. Multiple choice test & quizzes.	Opening/closure activities. Worksheets, verification labs & directed inquiry. Individual work. Quizzes & lab report.	Opening/closure activities. Video, worksheets, verification labs, & reviewing. Individual work. Quizzes & lab report.	Opening/closure activities. Worksheets. Individual work. Worksheet completion.
Emerging identities	Follower (offline) Watchful-follower (online)	Follower (offline) Watchful-follower (online)	Follower (offline) Watchful-follower (online)	Watchful-follower (offline)
Decreasing Use in IBIS Scores: Summary of Deborah's Case				
Teaching practices	Guided inquiries, labs, & reviewing activities. Small group work. Questioning, essay & diagrams.	Opening activities, worksheets, & verification labs. Individual & whole group. Short quizzes.	Opening activities, worksheets, homework, & reading assigned materials. Individual work. Matching & short answers.	Opening activities, worksheets & lectures. Individual & whole group. Assessment rarely used.
Emerging identities	Lonely follower	Lonely follower	Feeder (offline) Watchful-feeder (online)	Feeder (offline) Watchful-feeder (online)

perceived as unprofessional. This is because she thinks that sometimes teachers use videos for "filler," because they want a break, or that teachers use videos—or may be *perceived* to use them—when in actuality they have not planned adequately. Her online mentor, Gina, defends Rosy's practice of using videos by stating that videos are a perfectly valid and effective way to represent abstract concepts. A month later, Norma considers using a video in her class, and soon after that point, she is using more videos with her students.

> Message no. 382 posted by Norma:…We do have some really good videos, and the advanced class has some good questions about them. I agree that videos work best when they lead to discussions…

Deborah's Case: Changes in Deborah's Teaching Practices

Year one: September – December. Deborah, who is teaching physics out-of-field, finds most of her lesson plans on the Internet, but also uses lesson plans suggested by other teachers. Once she has decided on a lesson, she puts students in groups and tries to incorporate traditional and alternative assessment measures such as questionings, essays, and diagrams. She finds most of the activities on the Internet.

Year one: January – May. Deborah becomes more committed to using opening activities, and she is consistent in her use of worksheets and verification laboratories. Most of her lessons are from textbooks and the Internet, and her assessments consist primarily of quizzes that have only one correct answer.

Year two: September – December. Deborah's practices are similar, at the start of this year, to her practices at the end of the previous year. She uses opening activities, and has a main lesson that consists of completing worksheets, homework, and reading textbooks. She primarily uses traditional assessments (e.g., matching and short answer quizzes) and most of her lesson plans now come from textbooks. Similar to last year, Deborah tries not to ask questions of her colleagues. She doesn't feel they truly understand the content, so she just tries to deal with everything by herself.

> Both of us really don't know what to do, so we do everything together. And we don't have anything to compare to—we are just trying to figure out what is working or what isn't working within the class. [We] kind of try all [methods]. We just try to do things in a trial and error way. (Laughter) If it doesn't go well, we just won't teach [that way] again. (Weekly interview, September)

Year two: January – May. Deborah's science practices are similar to last semester, as she still incorporates opening activities for most of her lessons, and uses worksheets and lectures as individual and whole group organization.

Emerging Identities of Deborah

Lonely follower. *"I still feel in the dark most of the time. I'll take anything that you think could help."* Deborah, who was given physics modeling materials for her lessons, displays her confusion about how to use these materials, and additionally seeks help from her online mentor, Lucy. Lucy, however, does not answer Deborah's questions, or address Deborah's needs. Instead, Lucy avoids Deborah's questions, and tries to direct Deborah's attention to the requirements of the *OSSM program*. Lucy reacts to this by making a quick response to Deborah's questions and suggestions, and reframing the topics to *OSSM* tasks. By focusing only on project requirements, Lucy loses the opportunity to help Deborah learn how to teach inquiry. Finally, Lucy frequently forgets many details that Deborah describes over the year.

Feeder (offline) and Watchful-feeder (online). *"I just don't have the usual drive to make things fun and exciting for the kids. I am teaching them, but it isn't really in a way that I would like."* During the second year, Deborah teaches both physics and chemistry. In the absence of a mentor during the first year, Deborah relies primarily on lecturing. Her second year online mentor, Louisa, urges Deborah to try modeling her type of classes within her own chemistry classes. Louisa constantly reminds Deborah to register for the modeling class. Deborah, however, does not respond. Deborah is interested in inquiry, but she is trying to learn about inquiry by trial and error.

> Message no. 40609 posted by Deborah: …I feel like I am in survival mode [second year third quarter]… Of the other science teachers at the school, only two have actually taught chemistry. I get suggestions from them as much as I can, but we're pretty much up to our own devices…

DISCUSSION

Inquiry-based Instructional Strategies of Beginning Secondary Science Teachers

Overall, the beginning secondary science teachers' usage of IBIS is aligned with the knowledge base established by other scholars working on this topic (e.g., Anderson, 2002; Demir & Abell, 2010), in which the pervasiveness and sustainability of IBIS are not yet the norms in contemporary science classrooms. Yet, there are several findings that are worth discussing, in addition to the low IBIS scores among the beginning science teachers. First, the fact that the 14 beginning science teachers started out differently in terms of their IBIS and then gradually formed three different patterns of IBIS, although non-significant, during their first two years as science teachers, suggests the need for additional knowledge behind this phenomenon—and how to successfully support and encourage teachers to implement IBIS for student success. Here, Windschitl's (2002) framework of constructivism in practice accordingly provides some hints, in that successful enactment of IBIS can be achieved when beginning science teachers have chances to identify and confront what they know and believe about reform-based practices within conceptual, pedagogical, cultural, and political levels. Additionally, an important factor that needs to be studied is the development of negotiating skills for beginning science teachers, allowing them to resolve discrepancies between what they know and believe within these four levels.

Our three cases also demonstrate the complexity and difficulties of effective teacher changes towards inquiry-based science teaching practices. For instance, the teaching practices of Isabel, who was chosen to represent the group having an increasing use of IBIS, often consisted of instructional strategies that were sometimes not aligned with inquiry-based science teaching practices. Our findings indicate that a noticeable number of conceptual conflicts occurred between what she knew and believed, and the classroom realities within her school. These conflicts were identified when Isabel negotiated her teaching practices with those of the teacher next door, and with her instructional coach.

Practices and Emerging Identities

Knowledge based on the study of the practices and identity associated with the CoP allowed us to identify beginning secondary science teachers' changes in teaching practices and changes in their emerging identities. Especially, processes through which the concepts of 1) membership (e.g. core vs. peripheral), 2) multiple means to relate to the community through mutually related acts (e.g. oral vs. text), 3) private space vs. public space (e.g. online vs. offline), and 4) multiple modes of belonging in participation and/or non-participation (e.g. engagement, imagination, and alignment), were all interwoven with "doing and becoming." Our conceptual framework argues that practice and identity are parallel and evolve concurrently as time passes. Yet, we argue that changes in "practices" or "doing" are needed in order to nurture real shifts in "identity" or "becoming." Our three cases illustrated the interplay between teaching practices that consisted of IBIS and non-IBIS, and how corresponding identities emerged within each quarter—especially in the light of "negotiability" as defined by Wenger (2008).

Our findings indicate that the cultures of the schools that Isabel, Norma, and Deborah taught within considerably influenced both their teaching practices and their emerging identities. Especially, two common themes emerging that showed discrepancies between the new teachers and the cultures of the schools were 1) science as a disciplinary-universal subject and 2) beginning teachers as a "learner-of-being-a-teacher" (Isabel), as a "messenger" (Norma), and as a "ready-made teacher" (Deborah).

As for the first theme, the three beginning science teachers were all assigned to teach science disciplinary areas that were not within their fields of expertise, to varying degrees, over the two-year period. Isabel, who had a biology background, taught 7th grade general sciences. Norma, who had biology-background, taught earth science in her second year. Deborah, who was chemistry-disciplined but taught physics, consistently showed anxiety regarding her self-perceived lack of content knowledge in physics, her obsession of self-teaching her content via the Internet and, finally, confessing that lecturing or teacher-centered teaching strategies were the most comfortable teaching strategies.

As for the second theme, our findings indicate that the three beginning teachers were systematically and socially positioned differently at their school. As a result, they differed in their negotiation skills and strategies—ways in which they could integrate into their institutional settings. For instance, Isabel, whose school positioned her as a "learner-of-being-a-teacher," was able to practice many different identities at her school, and was also able to widen her roles, knowledge, and skills. The culture of her school offered a decided fluidity of interactions and transparencies between the new and the experienced teachers within the community. Due to these elements, the presence of conflicts in pedagogical content knowledge was ostensible between the two groups. This may have given Isabel more frequent opportunities to identify and expose her understanding in inquiry-based practices within conceptual, pedagogical, cultural, and political levels. These types of constructive conflicts were emphasized in the concept of "intellectual midwifery" in Grossman, Wineburg, and Woolworth's (2001) study, and the concepts of "illuminative hinges" and "growth buds," in Foot's (2001) study on the cultural-historical activity theory. Foot (2001) considers conflicts and contradictions as a sign of richness in a particular social community of teaching. These observations align with the work of Hodgen and Askew (2007), Kaasila, Hannula, Laine, and Pehkonen (2008), and Ross and Bruce (2007), in that the community-valued robust interactions, including collegial disputes among teachers, were regarded as healthy processes both inevitable and invaluable in fostering positive teacher changes.

Our second case, Norma, was located in a social setting where she was considered as a messenger of a ready-made curriculum. The actual delivery of the curriculum occurred with the help of teachers at the school. Within this environment, she had supportive administrators, and she was given most of the materials and lessons she needed to teach. While this support was valuable, it constrained Norma in the sense that she did not have adequate opportunities to contribute her own creativity and knowledge to the existing school curriculum. Her social setting expected Norma to accept, as is, both curricula and associated guidance offered, and to ultimately teach how and what the school wanted her to teach. She was situation within a community where conformists were valued and were viewed as good teachers. Norma practiced only a couple of identities during the two years, staying close to the learning trajectories of experienced teachers at her school. This somewhat superficial intellectual midwifery provided Norma few opportunities to identify and expose her understanding of inquiry-based practices. Yet, she was content as long as she followed the school curriculum. As a result, in this venue, interactions between the new and the experienced were one-sided, in that new comers had few chances of integrating their ideas and practices with the practices of their experienced teacher counterparts—much less in practicing and developing them further. Moreover, these one-sided dynamics made Norma believe that she was practicing inquiry, while in reality she was simply implementing teacher-centered instruction.

Finally, Deborah, our third case, was located in a community setting that lacked a sharing of ideas, and failed to provide sufficient chances to contemplate different and new ideas among members of the teaching community at large. We argued that her school considered her as a "ready-made teacher," where she was asked to create curriculum directly from a simple outline given by the science chair of her school. In addition, she wasn't given any orientation before or during her early months as a science teacher—only a textbook. Within this environment, many sources of cognitive dissonance were identified, such as her lack of confidence teaching physics that was out-of her field, fearfulness of her students noticing that she was not "competent," and a feeling of being lost—in the absence of significant interactions with other teachers at her school. She had insufficient chances to resolve these conflicts with the help of the school staff. Due to this relative rigidity in interactions among the members of her school community, Deborah conveniently implemented teaching practices that she was confortable with, and reminiscingly incorporated the familiar ways she had learned science teaching during her first two years as a science teacher. Through daily practices set by the schools, all three beginning teachers gradually, day-by-day, become viable science teachers within the cultures of their schools.

Online Subject-Specific Mentoring Program

Our findings indicated that participating in an OSSM program gave Isabel, Norma, and Deborah additional skills and powers of negotiation through which all three had opportunities of constructing identities that were somewhat different from the ones constructed within their institutional settings. As core members in an OSSM community, the three beginning teachers participated in mutually related acts through threaded online dialogues where their ideas were accepted and discussed through the "engagement mode" of belonging (Wenger, 2008). The OSSM program also encouraged the three beginning science teachers to vicariously participate in the telling and retelling of exemplary and painful stories with their online mentors, through the "imagination mode" of belonging (Bellah, Madsen, Sullivan, Swindler, & Tipton, 2008; Wenger, 2008). Within this online community, experienced practitioners—online mentors—actively explored and contemplated the practices of newly arriving science teachers. Bellah et al.'s (2008) concept of the maintenance and continuation of "a real community as a community of memory" (p. 153), argues that the stories of "collective history and exemplary individuals are an important part of the tradition that is so central to a community of memory" (p. 153). Although the actual teaching practices were different at their school, the three beginning teachers were persuaded to become inquiry-based teachers through the "alignment mode" of belonging.

There was no clear evidence that the OSSM program produced a significant impact on beginning secondary science teachers' IBIS. Yet, the study provides some answers to the complex process of beginning teacher changes. For instance, the OSSM program provided Isabel an opportunity to practice identities that resulted in her creating her own "change agency," around inquiry-based practices. Also, the social dynamics of online and offline experiences provided Isabel with sufficient opportunities for viable change. Norma who was content with her school curriculum, had the opportunity to engage in written dialogues where she was able to consciously identify and expose her current teaching practices. Finally, Deborah whose two-year participations at her institutional setting, appeared to disable her to some degree as an inquiry-based teacher, had opportunities to construct identities through online acts.

IMPLICATIONS

The findings of this study provide insights into identity construction through the use of practices, and the opportunity to interact with online and offline communities of practice with different memberships. The three beginning science teachers highlighted in this study developed identities as they practiced activities at their schools as peripheral members—Isabel by *negotiating* with other members in the community, Norma by practicing activities *given* to her by other members in the community, and Deborah by practicing activities created on her own. Yet, the presence of the OSSM program afforded them opportunities to transcend their institutional contexts and provided them with a place with a core membership to relate their own practices—as well as the practices of the experienced teachers through sharing stories. This enabled them to participate in acts related to the community of memory that permitted them to construct identities that are different from those constructed at their institutional settings (Bellah et al., 2008). Therefore, we suggest that mentoring program designers of beginning teachers consider the critical importance of involving new comers within the historical perspective of the community of practice.

AUTHORS' NOTE

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