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Teacher Transformation: An Exploration of Science Teachers' Changing Professional Identities, Knowledge, and Classroom Practices

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Abstract

This qualitative, multiple case study examines five teachers' experiences with a National Science Foundation-funded professional development (PD) program focused on science literacy. Using a three dimensional conceptual framework combining transformative learning theory, communities of practice, and sociocultural conceptions of identity it explores: the ways the "Science Literacy through Science Journalism" (SciJourn) project built professional community and influenced teacher learning; the influence of the project on participating science teachers' professional identities, knowledge, and classroom practices; and the ways teachers were or were not transformed by participation in the project. To this end, data from surveys and phenomenological interviews were analyzed through qualitative textual analysis and narrative analysis.

Four of the teachers experienced a change in their stories to live by, aka, an identity shift. Three predominant themes emerged across these cases. These included a changed conceptualization of science literacy, the importance of student engagement and authenticity, and the value of SciJourn's professional development and community. The changed conceptualization of science literacy was particularly salient as it challenged these teachers' assumptions, led them to rethink how they teach science literacy, and also influenced them to re-evaluate their teaching priorities beyond the PD. Consequently, this study concludes that PD efforts should focus as much, or more, on influencing teachers' ideas regarding *what* and *how* they teach and less on teaching strategies.

A close comparison between two teachers' diverging experiences with the program showed that student engagement played a significant role in teachers' perceptions of the value of project, suggesting that whether or not teachers sustain a new

practice is closely tied to their students' feedback. Additionally, this analysis showed that a teacher's individualized needs and sense of efficacy in implementing a specific reform effort are of consequence. Thus, in order to be influential, PD must somehow speak to a teacher's individualized needs, whether or not these needs are specifically stated at the program's onset. Aside from wanting to implement a project, a teacher also needs to believe that he or she is capable of successfully doing so.

In considering transformative learning theory as a conceptual framework, the research presented here gives evidence that certain phases of transformation may be more significant than others, and phase two (self-examination with feelings of fear, anger, guilt, or shame) should be expanded to include a wider range of emotions.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

How It All Began

My first year as a teacher, I taught science in an economically strapped, urban high school. During my first month of teaching, the district required that I attend a full-day professional development (PD) session on using SMART Boards. For seven hours, I watched and listened as the presenters showed us the wonders of this new technology. At the time, there was not one SMART Board in our building. My classroom had one blackboard, which was my only "technology." I did not have a computer or even an overhead projector, and the one copy machine in the school remained perpetually broken. Forty two students were assigned to my third hour class, and I only had enough seats for 36 of them. As you can imagine, learning how to use a SMART Board was low on my priority list as I attempted to navigate the unexpected challenges of my new profession. That was my first experience with ineffective PD, unfortunately, the norm for my school district. As I repeatedly sat through unproductive workshops, I was disquieted by the lack of relevance and concern for my specific needs as a teacher. I quickly learned that if I wanted to improve my teaching craft, it was on me to seek out valuable, relevant opportunities for professional growth.

Later, when I was chosen to work as an Instructional Coach for math and science teachers, PD became a central part of my job, and I continually looked for new ways to engage my teachers. Despite my best efforts, however, I often felt like my PD workshops fell short. For three years, I aspired to get my teachers to step outside of the box and try new strategies, but most remained unreceptive to my ideas; they just wanted me to leave them alone. The majority were frustrated and beaten down by the broken system we

called our job. Many had learned to accept mediocre results. As a professional, I spent significant time grappling with these issues and many late nights trying to overcome these barriers. This set me in pursuit of trying to understand how teacher change happens and how to cultivate quality PD.

Need for the Study

Historically, PD is reputed to be unsuccessful and is viewed as a waste of time by many teachers. Ann Lieberman and Diane Wood (2003) put it best when they describe the history of PD as a "landscape littered with failed approaches" (p. 2). These approaches commonly offer a one-size-fits all model and treat teachers as mere recipients of pre-packaged knowledge. PD is frequently offered as a one day workshop where an "expert" shares some new strategy, skill, or resource for the teachers to take back to their classrooms and put to use. This approach rarely takes into consideration teachers' individual needs or specific classroom contexts. In this manner, teachers are basically "in-serviced", an approach which positions them as technicians and "consumers of other people's knowledge" (Cochran-Smith & Lytle, 1993, p. 88). This kind of PD still dominates as districts invest in quick-fix initiatives designed to improve test scores.

So what exactly constitutes valuable PD? This is a question that researchers have spent countless hours trying to answer. Fortunately, many studies show that despite its poor reputation, there *are* specific approaches to PD that teachers find deeply valuable (Anderson-Levitt, 2002; Coburn & Stein, 2010; Cochran-Smith & Lytle, 1993; Lieberman & Wood, 2003). Not surprisingly these studies find that good PD focuses on the teachers themselves, acting as agents for their own learning. Furthermore, good PD recognizes that teachers do not work in isolation. Their learning is social and dynamic.

It is not surprising that the most productive models for PD foster dialogic learning and the development of intentional communities that nurture professional conversations. Ideally, teachers choose to participate in these intentional communities rather than being assigned to a particular group.

Educational reform networks are an example of such a model. These networks enable teachers to enrich their teaching, while also providing them with the support that is essential for enduring growth and development. The National Writing Project (NWP) is arguably one of the most successful educational networks. One of the foundations of the NWP is the notion that teacher development must combine new knowledge with a professional community, in which to continuously practice, improve and share. The NWP brings teachers into its teaching culture by enacting specific social practices that build this community. These practices include putting teachers at the center, respecting their knowledge, connecting them to peers, and providing them ongoing support (Lieberman & Wood, 2003). Educational networks like the NWP also represent an approach to PD wherein teachers function as primary actors in their own development. In other words, teachers choose to be a part of these programs. Mandated PD often does not work because it does not speak to teachers' individual needs.

University and teacher partnerships provide the basis for some of the most successful educational networks and PD programs. Coburn and Stein (2010) set out to explore these partnerships to uncover the ways research joins with practice to influence productive reform. Their study looks at ten nationally-known projects that had a track record and were considered successful. They found that while most programs focus on how teachers should teach, the most successful partnerships focused on how teachers

learn to teach. Thus, explicit attention to how teachers learn, and how they learn in different ways in different contexts is critical to transforming classroom practice.

By emphasizing collaboration, these educational partnerships occupy a "third space" (Lieberman & Wood, p.88). They are not limited to either university or school problem-posing and knowledge but bring these two realms together. This third space is the forum for collective dialogue and inquiry. While the participants are concerned with their local institutions they maintain a sense of autonomy outside of them. Inside this third space, the everyday concerns of educators are positioned against a larger horizon of educational issues. The knowledge that teachers have from working in the trenches informs the knowledge of reformers, researchers, and policy-makers. In other words, "inside knowledge" informs "outside knowledge" and vice versa (Lieberman & Wood, 2003).

While these successful models of educational reform networks have developed innovative approaches to PD, there is still much to be learned. Teacher participants in networks like the National Writing Project often called them "transformative." However, there is little information about what exactly the transformative experiences are, how they impact teaching practice, or what effects they have on student learning. As educational networks become more popular and more influential, it is increasingly important to understand them organizationally as well as understand their influence on teachers and students (Lieberman & Wood, 2003).

Science Literacy Through Science Journalism

The Science Literacy through Science Journalism (SciJourn) project, the subject of this study, is another example of an educational reform network. SciJourn, funded by

the National Science Foundation, was a partnership between university-based researchers, science journalists and classroom teachers that focused on using science journalism as a method to foster science literacy. Over the course of the project, 51 teacher participants came from a variety of contexts including: private and public schools; rural, urban, and suburban settings; high performing and struggling districts. Teacher participants, all of whom voluntarily applied to participate in the project, received free graduate credit, course materials, support for implementation, and modest stipends.

In each of the three full years of the program, new teacher participants joined SciJourn through an intensive two-week summer workshop (groups were designated Pilot, Cadre 1, and Cadre 2). During this workshop, teachers were introduced to the concepts of science journalism by a professional science journalist and editor, and were required to write and revise their own science news article for a teenage audience. Once approved by the editor, these articles appeared in the *SciJourner*, an online and print newsmagazine.

I chose to focus my research on SciJourn because the project was innovatively designed to include not only teachers and university-based researchers, but also working professionals, who brought a unique expertise to the project. This made SciJourn markedly different from other educational networks. Furthermore, SciJourn provided a model of successful, teacher-centered PD, which was intentionally designed to create a learning community where teachers could come together to engage in a dialogue about ways to enrich their methods for teaching science literacy. However, the success of SciJourn's PD went beyond being teacher-centered and community based. Unlike most

PD, it was not focused on how teachers teach but rather how teachers learn. It was not about creating lesson plans or giving formulaic guidelines for implementation. Instead, SciJourn's training focused on authentically teaching educators about science journalism as a genre, while also asking them to think about science literacy in a new, innovative way.

My SciJourn Story

Growing up, formalized science education had little influence on me. I went to a small, Catholic elementary school where teaching science was not a priority. Once I progressed to high school, science was primarily taught out of a textbook. My passion for science does not stem from the classroom but instead, is deeply rooted in my love of nature. I grew up playing outdoors. I have fond memories of running barefoot through the grass and building tree forts with my older brother and our neighborhood friends. My grandparents also owned a small family farm, which is where I learned to ride horses and watched my grandmother garden. I started attending an ecology focused summer camp when I was ten years-old. The camp was primitive; we lived in tree houses with only three walls, a roof, and no electricity. It was there that my love for the outdoors turned into a real interest in science as I learned about various conservation practices. I attended that same camp for five years and then continued to work there as a counselor until I was 20 years-old, which was pivotal to my pursuing an Environmental Science degree in college. To this day that same camp remains influential in my life; my family and I continue to volunteer and visit there several times throughout the year.

While I loved being outdoors, I also loved reading books. During my summer breaks, my mother and I took weekly visits to our local library. If I was not outdoors

playing, I could be found curled up in a corner of our sofa reading. When I got to high school, I had an exceptional English teacher who introduced me to the wonders of British literature. In her class, I found myself smitten with the likes of Beowulf, the Canterbury Tales, and the works of Shakespeare and Milton. She was also the teacher who taught me how to write an academic paper. Because of her class and my love of literature, I decided to double major in college, studying both English and Environmental Science.

I did not become a teacher until I was 27 years-old. After college, I headed to Australia on a scholarship to study Aboriginal folklore and to pursue a Master's degree in English. When I returned to the United States a few years later, I landed in the professional niche of medical writing when I accepted a job as an editorial assistant at a cardiology journal. I spent the next few years doing editorial work for medical journals and pharmaceutical companies. Though I enjoyed the work, I was not fulfilled and found myself re-evaluating my career path. Since my days as a camp counselor I had always enjoyed working with kids. Teaching had always been in the back of my mind as a potential career, so I started taking classes at a local university to get my teaching certification. It was going to take a few years, however, so I explored alternative options. A close friend of mine put me in touch with Teach for America (TFA), an AmeriCorps program. I discovered that through TFA, I could start teaching the next year. I immediately applied and was accepted into the program. The following summer, I moved to St. Louis to begin teaching at an inner city high school. I had assumed, because I had a Master's degree in English, that TFA would place me in communication arts, but I ended up getting placed in a high school biology classroom.

The district where I taught was an urban, high needs district, and I was placed in one of the largest and most challenging comprehensive high schools. My first year as a teacher was rough. I was acutely aware that my students were immersed in a culture of low expectations, and I felt strongly that they deserved better. I had no clue what I was doing, but I was constantly trying to improve my craft. So I just kept trying new strategies until I found some that worked. It took me a few years, but I eventually developed my identity as a teacher and began to thrive in the classroom. Teaching made me excited about science in a new, geeky kind of way, and ultimately, made me fall in love with the subject all over again. I found that getting kids interested in science was easy when I could relate it to their world. So I made that my goal, to relate everything I taught to the lives of my students. Doing so meant a hands-on, student-centered learning environment. That approach enriched students' understanding of the content and also resulted in a higher level of student engagement. It also resulted in higher test scores. My students, at one of the lowest performing schools in the district, were consistently scoring above the district average on our benchmark assessments. This not only reinforced my belief in what I like to call "the magic formula" (high expectations coupled with student-centered teaching) but also empowered me as an educator. Because of that success, at the end of my fifth year in the district, I was transitioned into the role of an instructional coach, where I was asked to share my approach to teaching and my classroom management strategies with other teachers.

Because of my background in English, I felt that reading and writing should be taught across the curriculum, and I tried to make literacy a central component of my science classes. I struggled to do so, however, because biology was a tested subject and

my curriculum was packed tight. When I began working as an instructional coach, I worked closely with my science teachers and was constantly looking for ways to help them integrate literacy practices into their teaching. Consequently, when I was introduced to the SciJourn project during its third year, I was eager to jump on board. I participated not only for my own benefit but also in hopes that I would learn something meaningful that I could take back and share with my teachers.

Ultimately, participation in the SciJourn project transformed my thinking and instructional practices around science literacy. The project gave me a new way to frame science literacy for my teachers and also equipped me with a toolkit of strategies to share. I worked closely with one of my teachers to implement the project in two, 12th grade anatomy and physiology classes. Though none of our students published articles, I saw first-hand the positive influence of the project on both the students and the teacher.

Since then, I have transitioned to being a full-time graduate student and researcher. My own experiences with the SciJourn project were profoundly influential in guiding this research. I knew from my own perspective that the project resonated with me on a level that no other PD ever had. I left feeling tremendously inspired and found myself thinking about teaching science literacy in a completely different kind of way. Knowing that I was not the only teacher who felt this way, I sensed that there was something powerful going on, and I wanted to probe the experience further. That was really the point of departure for the research presented here. It was only natural that the researcher in me sought to understand the transformative power of this project on a deeper level. And while I sought to understand the transformations that took place, I also wanted to examine the other side of the coin, considering closely why some teachers

might not have been positively influenced. In the end, I was acutely aware that my experiences with the project were part of the conceptual baggage that I brought along with me on this journey. My hope is that through exercising continual reflexivity, these conceptions enriched this project rather than constrained it.

Purpose

The purpose of my research was two-fold. Originally, I sought to explore the ways science teachers integrated SciJourn activities into their classrooms. In this way I hoped to gain an understanding of teachers' appropriation of SciJourn concepts, which would give me insights into SciJourn's influence on them and their teaching identities. What's more, several science teachers had claimed that the project changed how they taught, yet we did not have clear insights into what exactly about the experience impacted them or the specific ways it influenced their teaching practices. Ideally, this research will also influence designers of science PD, as well as teachers. The work presented here sheds light on how to design similar programs and future successful collaborative partnerships between universities and practitioners.

Specifically, I was interested in SciJourn as a *transformative learning experience* for science teachers. By transformative, I am specifically referring to learning experiences that have influenced a change in teachers' professional identities. I was also interested in the collaborative nature of SciJourn as well as the social practices that might have established SciJourn as a community and network of learning. Ultimately, I wanted to know *what* transformed teachers and *how* this transformation happened. Understanding this process of transformation required that I look closely at the teachers' experiences from multiple angles, considering not only the impact of the experience on

them professionally, but also on their thinking and teaching. Thus, the following research questions guided this project:

- How did the SciJourn project build professional community and influence transformative learning?
- How did participation in the SciJourn project influence science teachers' professional identities, knowledge, and classroom practices?
- In what ways were teachers transformed?
- Why were some teachers transformed by their participation in the project, while others were not?

Conceptual Framework

The primary conceptual framework used in this study was transformative learning theory, which is commonly used to understand adult learning and the implications of teaching adults. Transformative learning is the process of examining, questioning, validating and revising our perspectives. More specifically, if a person responds to an alternative habit of mind by reconsidering and revising prior belief systems, the learning then becomes transformative (Mezirow, 1991). As I sought to understand this process of transformative learning, I also drew on elements of conceptual change theory, which is concerned with the ways learners make the transition from one conception to another (Strike & Posner, 1992). This framework provided a useful lens as I explored how participation in SciJourn challenged the participating teachers' assumptions around science literacy and forced them into a place of critical reflection. Similarly, the notion of self-efficacy emerged as an important idea, particularly as I compared two of the teachers' contrasting experiences with the project. Self-efficacy theory is based on

Bandura's (1977) model, which suggests that individuals' self-efficacy beliefs influence their goals, the amount of effort they invest, as well as their resilience when facing challenges. As I explored why one teacher experienced transformation and another did not, this notion of self-efficacy was useful in helping me to understand how one specific phase of transformative learning proved to be critical.

One of the criticisms of transformative learning theory is that it does not adequately attend to the context of one's experiences. Consequently, sociocultural conceptions of practice are used to examine more fully the context of the SciJourn project. Sociocultural scholars posit that learning is based on social interactions, prior knowledge, experiences, language, culture, and context (Lave, 1988; Lave & Wenger, 1991; Vygotsky, 1978; Wenger, 1998). Though there are many dimensions of sociocultural conceptions of practice, I specifically called on the work of Wenger (1998) to analyze SciJourn as a community of practice. In so doing, I considered SciJourn's PD and the ways participants were invited into, settled into, and took up particular practices of that community of learners.

Sociocultural conceptions of identity also informed this study. Sociocultural conceptions of identity are based on the notion that people construct various identities for themselves in different contexts (Gee, 2000; Holland, Lachicotte Jr., Skinner, & Cain, 1998; Sfard & Prusak, 2005; Wenger, 1998; Wortham, 2006). Here, I used sociocultural conceptions of identity as a pivot between the social and the individual. Subscribing to the idea that transformative learning does not only alter one's perspective but also influences a change in identity, I applied identity concepts as I sought to understand the influence of participation in the SciJourn project on teachers' professional identities.

Connelly and Clandinin (1999) understand teacher identity as storied, attending to the ways teacher tell their stories as well as when, where, and to whom their stories are told. Thus, I drew on their notion of "stories to live by" as a representation of teachers' professional identities and considered how a change in a teacher's story to live by is a manifestation of transformative learning.

Research Design

"Understanding teaching requires that we pay attention to teachers both as individuals and as a group, listening to their voices and the stories they tell about their work and their lives" (Elbaz-Luwisch, 2007, p. 359). The research presented here is a multiple case study that used qualitative data collection strategies, drawing heavily on phenomenological techniques. I employed qualitative methods because I sought to preserve the voices of my research participants, while the multiple case study design allowed me share multiple teachers' stories. I used survey-data for my case selection and in-depth individual interviews to report on teachers' experiences. Because I wanted a compelling account, the study was grounded in in-depth interviews as I sought to access the essence of the teachers' experiences. I also included data from an interview held with two of the developers of the project. This gave me insights into the developers' perspectives as well as a more specific understanding of the ways the project evolved throughout its five years. I analyzed the data using a coding process to identify the emergent themes and categories. Once stable categories and sub-categories were identified, I returned to the data and used the tools of narrative analysis to extract particularly salient narratives for each participant. These narratives painted the picture of

each science teacher's experience and gave insights into the ways the project influenced their knowledge, professional identities, and classroom practices.

Limitations

Since this study looked very closely at the teachers' experiences on a deep level, I was limited in the number of cases I was able to include. As much as I would have liked to include several teachers from each cadre, time limitations did not allow for it. However, because this study only focused on five teachers, I was able to paint a richly detailed account of each of their experiences.

In the end, I was, and still am, deeply committed to this work because I believe, rather strongly, that PD can be tremendously valuable for educators. However, in many cases, PD for teachers is unsuccessful. I would like to see successful, transformative PD become the norm rather than the exception.

Structure of this study

Following this introduction, in chapter 2, I explore the conceptual frameworks used in this study in more detail. I also situate the study in the context of relevant scholarship on teacher PD. In chapter 3, I explain my epistemological choices and describe the qualitative methods employed in this research. I introduce the SciJourn project in chapter 4 and situate the project in the context of relevant scholarship on science literacy and writing in science. I also offer my interpretations of my interview with the project's designers, examining closely the evolution of the project's definition of science literacy as well as the intentional design of the PD. In chapter 5, I introduce each of the cases and explore each teacher's experience with the project in detail. I closely investigate teacher transformation while considering the influence of the project on each

teacher's professional identity. I then present the cross-case analysis in chapter 6 where I investigate the similarities and differences in the teachers' stories and examine participation in SciJourn as a transformative learning experience. In chapter 7, I take a closer look at two teachers' diverging experiences with the project. I then conclude the study in chapter 8, reviewing my interpretations and revisiting the conceptual frames that informed this work. I also consider the implications for practice and make recommendations for future research.

Chapter 2: Conceptual Framework and Literature Review

Overview

In this chapter, I begin by situating the study within the conceptual frames of transformative learning theory, communities of practice, and sociocultural conceptions of identity. I point to the gaps in the research, demonstrating that transformative learning theory can become more cogent when used in concert with other theoretical lenses. I then explore the literature on teacher PD and provide an overview of models that have been successful in fostering teacher growth and change. In this review of the literature, I establish how this study adds to the body of knowledge on science teacher growth and development by exploring teachers' experiences with the SciJourn project through a unique combination of conceptual frameworks.

Conceptual Framework

Transformative learning theory was the primary analytical lens used in this study as I sought to gain deep insights into teachers' experiences and their evolving perspectives around science teaching. However, as a theory in progress, transformative learning theory is limited in its scope. Consequently, I also drew on elements of sociocultural conceptions of practice and sociocultural conceptions of identity. Using these theories in concert was useful in overcoming the limitations and criticisms of transformative learning theory while also bridging the divide between individual and social perspectives on learning.

Transformative learning theory. Transformative learning theory is primarily used in the field of adult education and is based on the idea that transformation occurs when there is a deep shift in perspective. This theory is a useful point of departure for

understanding teacher learning and the ways teachers are influenced to change their teaching practice. The theory has roots in Jack Mezirow's (1978) grounded theory study of adult women returning to higher education. Though the theory originated in this study, Mezirow's first presentation of transformative learning theory was in *Transformative Dimensions of Adult Learning* (Mezirow, 1991). In this work, Mezirow posited transformative learning theory as an explanation of how adults learn, transform, and develop. His theory was strongly influenced by the development of adult learning theory, while also drawing on psychology, psychotherapy, sociology, and philosophy. Mezirow's theory was also founded on constructivist assumptions and is based on the view that learning is dependent on an individual's experiential world. From this perspective, learners reconstruct their knowledge as they integrate or reformulate their learning with prior experiences. Thus, transformative learning occurs through the process of questioning, analyzing, and reformulating those experiences (Mezirow, 1991).

Mezirow also draws heavily on Freire's (1970) notion of "conscientization," where individuals become conscious of their old perspectives and begin to see themselves as having choices for controlling their own lives. He attributes Freire as extending the possibilities of using education to transform one's frame of reference to lead to both personal and social change. Mezirow suggests that we develop habitual expectations based on our prior experiences, and we uncritically assimilate various perspectives from our community, culture, and social world. Those perspectives inherently guide our decisions and actions, and when we encounter a situation that does not align with our expectations, we may enter into a learning process that could lead to a transformed perspective (Mezirow, 1991).

Transformative learning theory - An overview. The origination of the theory is based on the notion of meaning perspectives: "A meaning perspective refers to the structure of cultural assumptions within which new experience is assimilated to - and transformed by - one's past experience. It is a personal paradigm for understanding ourselves and our relationships" (Mezirow, 1978, p. 101). However, since its origination, Mezirow (2000) has expanded the theory to include frames of reference, habits of mind, and points of view (Figure 1). Frames of reference are the web of assumptions and expectations that influence how we see the world. Our frames of reference anchor our values and sense of selves, and we have the tendency to embrace frames of reference that enhance each other. A frame of reference is made up of two dimensions, a habit of mind and resulting points of view. Habits of mind are the assumptions used to interpret experiences. These habits of mind are expressed as our points of view, a series of meaning schemes, which are habitual and implicit. Points of view are used to interpret our experiences; they determine what we see and how we see it.

Mezirow (2000) describes four ways that learning occurs: elaborating existing frames of reference, learning new frames of reference, transforming points of view, and transforming habits of mind. He suggests that we can change our point of view by trying on another's point of view. We cannot, however, try on other's habits of mind since they are so intricately woven into our unique selves. Kitchenham (2008) argues that this distinction between point of view and habit of mind is critical because habits of mind make up our belief system and are more difficult to influence than our points of view.

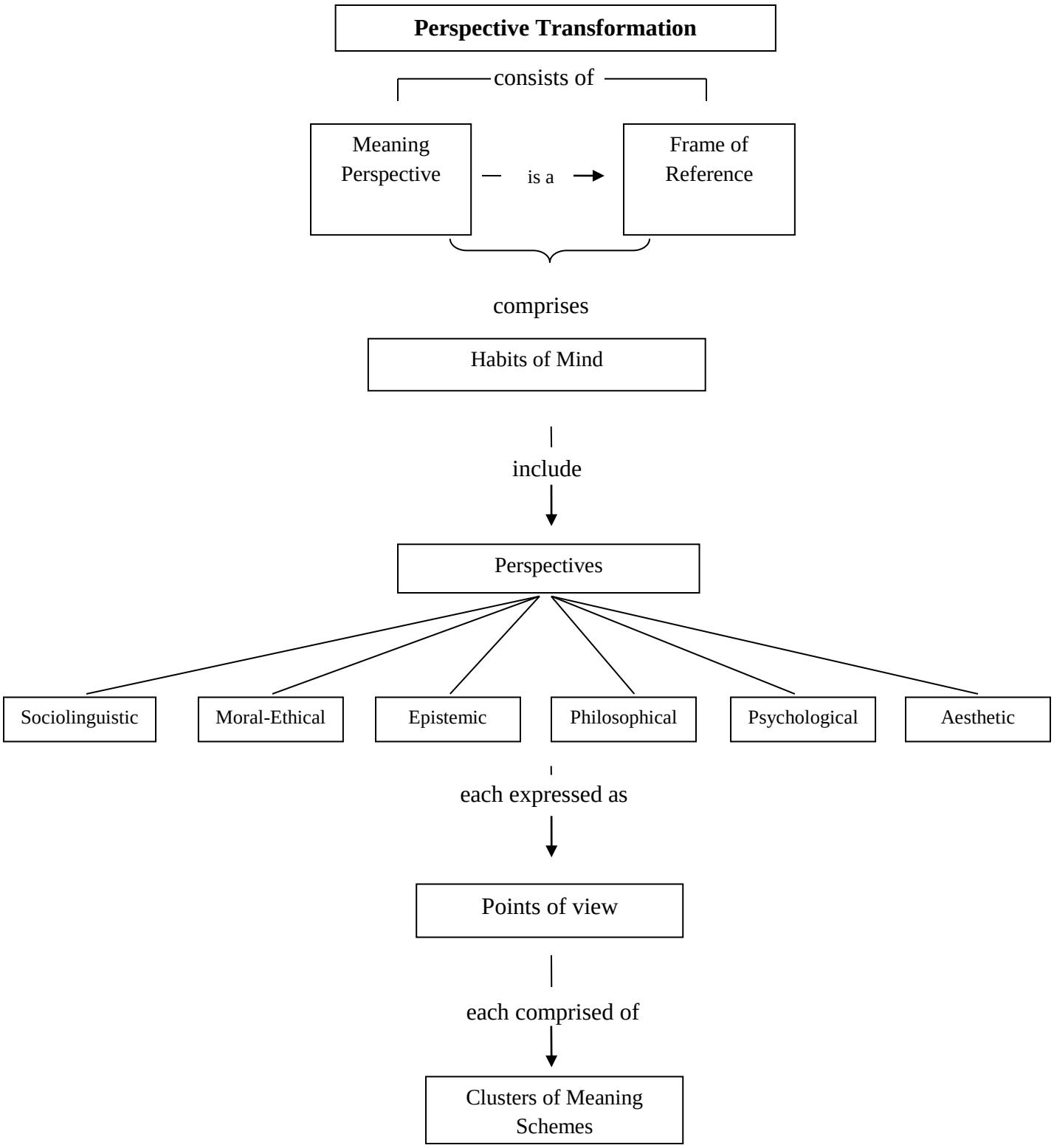

Figure 1. Diagrammatic Representation of Mezirow's Revised Transformative Learning Theory (Kitchenham, 2008)

In his work, Mezirow (2000) distinguishes between six habits of mind:

1. Sociolinguistic habits of mind are based on social norms, culture, and the way we use language.
2. Moral-ethical habits of mind include our conscience and morality.
3. Epistemic habits of mind are those related to how we learn.
4. Philosophical habits of mind stem from our world view, philosophy, or religion.
5. Psychological habits of mind refer to personalities and the ways we see ourselves. These include our self-concept, needs, inhibitions and fears.
6. Aesthetic habits of mind encompass our attitudes, tastes, and notions of beauty.

Though they are distinct, these habits of mind can also be viewed as interrelated because they are uniquely determined by one's personal experiences, background, culture, and personality. Ultimately, transformative learning occurs when we encounter an alternative perspective that leads us to call into question our prior habits of mind. These transformations in habits of mind may be *epochal* or *incremental*. Epochal transformations are sudden and dramatic, often triggered by a single, striking event (what Mezirow refers to as the disorienting dilemma). Incremental transformations involve a series of transformations in related points of view, which result in a cumulative transformation in habit of mind.

Transformations often include the following phases in some variation or another:

1. A disorienting dilemma
2. Self-examination with feelings of fear, anger, guilt, or shame

3. A critical assessment of assumptions
4. Recognition that one's discontent and the process of transformation are shared
5. Exploration of options for new roles, relationships, and actions
6. Planning a course of action
7. Acquiring knowledge and skills for implementing one's plans
8. Provisional trying of new roles
9. Building competence and self-confidence in new roles and relationships
10. A reintegration into one's life on the basis of conditions dictated by one's new perspectives. (Mezirow, 2000, p. 22)

Additionally, transformative learning may occur as a result of objective or subjective reframing. Objective reframing is critical reflection on the assumptions of others, while subjective reframing is critical reflection on one's own assumptions.

Mezirow (2000) argues that reflective discourse is central to transformative learning. He defines reflective discourse as a specialized kind of dialogue devoted to the search for common understanding, an attempt to tap into collective experience. This necessarily involves the assessment of beliefs, feelings, values, and assumptions. Participation in this kind of discourse requires an emotional maturity where individuals practice awareness, empathy, and control, which is why transformative learning theory is commonly used in adult education. Furthermore, individuals must participate in the discourse on their own accord. In other words, people make the choice to engage with a new and different perspective. Participation is not about being right but rather, involves finding agreement, welcoming differences, seeking synthesis, reframing, and trying on other points of view. It also requires that individuals feel safe and have support as they

explore others' ways of knowing and being. This kind of reflective discourse is integral in helping individuals to understand their experiences as they engage with and consider alternative perspectives.

In addition to reflective discourse, critical reflection is essential. Critical reflection involves questioning one's own presuppositions and habitual patterns of expectations. It means reassessing ways of perceiving, knowing, believing, feeling, and acting. Hence, transformative learning involves a critical discourse that leads to critical reflection through the examination of the assumptions that underpin one's judgments and actions. When individuals consciously choose to take action on these reflective insights, transformative learning may occur.

Mezirow (1991) distinguishes between three different forms of reflection: content reflection, process reflection, and premise reflection. Content reflection is reflecting on what we have learned. This form of reflection is based in the question, "What do I know?" Process reflection is reflecting on how we have learned. Process reflection centers around the question, "How do I know my method of problem-solving works?" Premise reflection results when we question the very presuppositions that underlie our knowledge and reflect on whether these presuppositions are warranted. During premise reflection, we engage in critical reflection and might ask, "Why should I attend to this problem?" (Kreber, 2004).

This process of critical reflection had important implications for the research presented here. Examining the ways the SciJourn project stimulated critical reflection for the teacher participants was useful determining how the project challenged their

assumptions around science teaching and learning and thus, resulted in transformative learning.

A theory in progress. Though Mezirow's work provided the foundation for transformative learning theory, the theory has expanded significantly in the past thirty years resulting in various tensions. Currently, there are numerous perspectives, which shape the various understandings of transformation. Early on, Mezirow was criticized for focusing on the individual and not on social transformation (Taylor, 1997; Taylor & Cranton, 2012). Another critique is that Mezirow's theory is too centered on rationality and does not attend to the ways individuals learn through emotions, spirituality, or embodied forms of knowing (Cranton, 2006; Dirkx, 2001). In response, other researchers have sought to develop an expanded model of transformative learning theory.

Dirkx (1997) emphasizes the extrarational perspective of transformation as he explores learning through soul. He argues that emotions are a kind of language that assist in learning. Moving beyond the analytic, reflective, and rational processes described by Mezirow, Dirkx seeks to understand more clearly what it means to foster transformation on the emotional level. Similarly, Brookfield (1987) argues that imagining alternative perspectives requires that individuals break away from rational modes of thought and tap into their creativity. Based on their study of adult educators as learning companions, Cranton and Wright (2008) argue that transformative learning needs to attend to an individual's whole being, not just the rational or the emotional, but both. Additionally, Merriam (2004) argues that mature cognitive development is essential if one is to engage in critical reflection and rational discourse. However, she suggests that even cognitively mature individuals are not always aware of their transformations. She suggests, then, that

critical reflection may not always be necessary for transformations, arguing that some transformations may occur through assimilative learning. She, too, pushes for Mezirow to expand his theory to include more affective and intuitive dimensions.

Consequently, two differing stances on transformative learning have evolved. The first, which is based on Mezirow's work, is rational, analytic, and cognitive. The second considers transformational learning as intuitive, creative, and emotional. While these two stances may appear to be distinct, they are interrelated. The rational process can move into emotional and imaginative terrain while the creative process can also incorporate analysis (Grabove, 1997). Currently, scholars are seeking a more unified theory where these two paradigms co-exist and are seen as complementary rather than as opposing viewpoints (Taylor & Cranton, 2012). In this study, I relied on this expanded, interrelated understanding of transformation as I sought to explore teachers' experiences on both a cognitive and emotional level.

Mezirow is also criticized for his lack of attention to context. Clark (1991) argues that the goal of transformative learning theory is to understand the meaning of experience and that context, itself, is the element that brings forth that meaning. Fostering transformative learning is never a one-size-fits-all approach. It is unique to each individual and is dependent on experience, relationships and educational settings (Grabove, 1997; Taylor & Cranton, 2012). Therefore, exploring context and meaning more explicitly would expand the cogency of transformative learning theory. Dirxx (1997) posits that through community and connection, transformative learning paradoxically leads to a greater sense of oneself. It implies “a complex, transactional relationship between the individual and the context of his or her life” (Dirkx, 1997, p.

10). As a result of these criticisms, both context and sociocultural factors have grown increasingly important as scholars have begun to attend to the social nature of transformative learning. Though Mezirow's theory emphasizes individual learning and is based on constructivist ideas, he also argues that discourse and social support are integral to the process. Transformation is also dependent on authentic relationships, which provide the genuine discourse that is necessary for in-depth reflection. Thus, transformative learning is found at the crossroads between the individual and the social, a result of interactions with others and personal change (Taylor & Cranton, 2012).

***What is transformation*?** As Mezirow's theory has expanded to include the work of other scholars, there has been debate about what "form" transforms. Mezirow defines transformative learning as:

> the process by which we transform our taken-for-granted frames of reference (meaning perspectives, habits of mind, mind-sets) to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action. Transformative learning involves participation in constructive discourse to use the experience of others to assess reasons justifying these assumptions, making an action decision based on the resulting insight. (Mezirow, 2000, p. 8)

Brookfield (2000) criticizes the indiscriminate use of the word "transformative" and argues that an act of learning can only be called transformative if it leads an individual to question and reorder his or her thinking. Tisdell (2012) posits that some learning transforms ways of being whereas others transform ways of thinking, and occasionally, there are overlaps between the two. Kegan (1994) suggests that transformational learning

occurs when an individual alters "not just the way he [*sic*] behaves, not just the way he feels, but the way he knows --not just what he knows but the *way* he knows" (p. 17). Thus, transformation is changing the very *form* of oneself. Grabov (1997) refers to this as a form of renewal and rebirth. The actual process of transformative learning, then, is essentially one of identity formation and reformation (Poutiatine & Conners, 2012). This notion of transformation as altering one's *identity* was integral to this study and set the foundation for my work as I sought to explore the influence of SciJourn on teachers' professional identities.

Fostering transformative learning. In recent years, much of the research on transformative learning focuses around fostering transformative learning. This research seeks to understand and make sense of transformative learning as a practice. Mezirow and Taylor's work, *Transformative Learning in Practice* (2009) provides specific instructional guidance to practitioners. As he reflects back on the chapters in this text, Taylor identifies six common practices that help to facilitate transformative learning:

1. Transformative learning as a purposeful and heuristic approach where the goals are to teach for change.
2. Transformative learning as confronting power and engaging difference through awareness of power structures and their influences.
3. Transformative learning as imaginative process that includes both the rational and the extrarational.
4. Transformative learning as leading learners to the edge, maintaining a balance between challenge and comfort.
5. Transformative learning as fostering reflection.

6. Transformative learning as modeling, where teaching is a living practice.

Together, these practices create a fertile ground for transformative learning to occur. To this end, Dirkx (1998) argues that transformative learning represents a potential that is always present in learners. He views transformative learning more as a way of *being* rather than a process of *becoming* and suggests that it is a stance taken toward learners rather than a strategy used on them.

In considering transformative learning in the context of teacher PD, Poutiatine and Conners (2012) look closely at the transformation of school principals. They argue that much of what is considered PD is about teaching educators new skills or ways to cope but does not necessarily challenge their assumptions. They suggest an alternative kind of PD that challenges limiting beliefs and assumptions while pushing participants to contemplate new perspectives. Similarly, Swanson (2010) suggests that reflective practice in PD helps teachers develop a systematic method of looking at their teaching and learning while at the same time transferring those understandings to their classrooms. She advocates for a learning partnership model of self-authorship that validates the teachers as learners, situates learning in their own experiences, and defines learning as mutually constructing knowledge. Cranton (1996) argues that many PD workshops emphasize instrumental knowledge. However, those that include group work and deep discussion that leads to the sharing of experience can stimulate transformative learning, especially when there are a series of workshops held over time. In her work exploring teacher transformation in the NWP, Whitney (2008) found that the turning point for teachers was the point at which their meaning perspectives were modified and new ones were adopted. The study presented here adds to Whitney's (2008) work by exploring the

particular meaning perspectives that are reframed by teachers through learning experiences.

Summary. Though researchers over the last thirty years have begun to explore the effectiveness of transformational practices, scholars have only scratched the surface of understanding the elements that are essential to transform learning (Mezirow & Taylor, 2009). In his most recent review of the research using transformative learning theory, Taylor (2012) identifies several areas for further research. He argues that other conceptual lenses can offer new insights into transformative learning when they are used to address the assumptions or concepts that Mezirow's perspective does not adequately capture. These varying conceptual frameworks can help us better understand the nature and practice of transformation. Additionally, he argues that more research needs to be done on the social nature of transformative learning, particularly the various ways context influences the process of transformation. To this end, this study used transformative learning theory while also drawing on elements of socicultural conceptions of practice and sociocultural conceptions of identity. In so doing, I sought to bring forth the social and contextual nature of teachers' learning, thus, bridging the divide between the individual and the social.

Sociocultural conceptions of practice. Context was an important piece of this study as I considered the specific ways teachers appropriated SciJourn concepts and made them their own. Consequently, I also drew on aspects of sociocultural conceptions of practice as I sought to understand the influence of both personal and sociocultural factors on teachers' experiences. Sociocultural conceptions of practice establish human action as mediated by language and other symbolic systems within particular cultural contexts.

Activities are viewed as social practices that are situated within communities. There are several strands of sociocultural conceptions of practice, and central to all of them is the notion that transformations in human thought and behavior do not arise from within an individual's own cognition. Rather, based on Vygotsky's theory of mind and culture (1978), thought and action develop based on culture. Enciso writes:

> Thought develops in the world and with cultural resources through its limitless capacity to invent, reinvent, interpret, and use such things as metaphors, concepts, objects, and implements. At the same time, the tools themselves – the mediational means available within a cultural milieu – undergo transformations in the particular contexts in which they become generative and useful for the construction of ways of being and thinking. (2007, p. 52)

In this way, cultural materials are changed as well as the individual who encounters and experiences the social, cultural, and historical meanings available in those materials. Thus, sociocultural conceptions of practice emphasize the intersection of individuals, cultural forms, and social positions within particular historical worlds.

Transformative learning theory is based on constructivist assumptions that emphasize individual cognition and learning. Sociocultural conceptions of practice, however, positions learning as socially and culturally situated. While these theoretical perspectives often appear to be in conflict, according to Cobb (1994) learning should be viewed as both a result of individual construction and a process of enculturation. In his research on mathematics education, Cobb explores ways of coordinating these constructivist and sociocultural perspectives. He suggests that the sociocultural perspective gives rise to theories about conditions of learning, whereas the constructivist

perspective focuses on what and how individual students learn. He also argues that an individual student's mathematical activity cannot be adequately accounted for without considering both the student's participation in classroom practices and the ways those classroom practices enable and constrain individual learning; thus, each of the two perspectives tells half of the story, and they can be used to complement each other. In this joint perspective, which Cobb and Yackel (1996) refer to as the "social constructivist or emergent approach" (p. 178), social norms evolve as individuals reorganize their beliefs and knowledge, and conversely, the reorganization of these beliefs and knowledge is influenced by evolving social norms. Essentially, the emergent approach takes both the individual and community as points of reference and seeks to understand both the development of the individual and the social communities in which individuals participate.

The social constructivist perspective offers a bridge between transformative learning theory and sociocultural conceptions of practice. Together, these two traditions were useful for gaining a deeper understanding of the ways transformative learning occurred within the SciJourn project. An in-depth examination of the social practices enacted within the project established how SciJourn built community and the ways that these practices enabled or constrained transformative learning. Doing so provided a deeper understanding of the context of SciJourn and the ways it influenced teachers' experiences.

Communities of practice. To this end, SciJourn was analyzed as a community of practice (Lave & Wenger, 1991; Wenger, 1998). According to Wenger (1998), a community of practice is defined by three dimensions: mutual engagement, a joint

enterprise, and a shared repertoire. Mutual engagement is not synonymous with being on a team or in a network. Rather, mutual engagement defines the community and requires that individuals create dense relations organized around their shared purpose. In doing so, individuals find their unique identity within the community, which becomes increasingly integrated and defined by engaging in the shared practice. Mutual engagement means that individuals bring with them unique gifts and perspectives, while also drawing on the strengths and competencies of others; what Wenger refers to as "complementary contributions" (1998, p. 76). A joint enterprise does not imply that all participants are in agreement, but rather, that the enterprise is communally negotiated. In this way, responses are coordinated and interconnected as members of the community come together to negotiate their shared practice. This joint enterprise also fosters mutual accountability among those in the community. A shared repertoire "includes routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions or concepts that the community has produced or adopted" (Wenger, 1998, p. 83). This repertoire also includes the discourse by which the community creates meaning and by which they express their forms of membership and their various identities. In sum, communities of practice provide an ideal context for the negotiation of meaning, both positively and negatively and have the potential to be a source of real transformation, having a profound impact on members' lives. As I sought to understand how SciJourn's PD built professional community, it was useful to examine the project as a community of practice and the ways the project was intentionally designed to facilitate teacher transformation.

Wenger (1998) argues that learning cannot be designed but rather, it can only be facilitated. He writes, "One can design systems of accountability and policies for

communities of practice to live by, but one cannot design the practices that will emerge in response to such institutional systems" (1998, p. 229) From his perspective, practice is not the result of design but instead is a response to design, and the challenge of designing learning experiences is to include the emergent, the "inherent uncertainty between design and its realization" (Wenger, 1998, p. 233).

Though learning cannot be designed, we can develop conceptual architectures that support learning. Within Wenger's framework (1998), communities of practice are fundamental to these architectures. They are characterized by four dimensions: negotiation of meaning, preservation and creation of knowledge, spreading of information, and home for identities. Communities of practice are what Wenger (1998) refers to as the "social fabric" of organizational learning, and an organization's learning depends on its ability to foster communities of practice.

From Wenger's (1998) perspective, the essential purpose of educational design is to foster learning communities. He writes, "Once learning communities are truly functional and connected to the world in meaningful ways, teaching events can be designed around them as resources to their practices and as opportunities to open up their learning more broadly" (p. 271). Fostering learning communities requires the inclusion of three design components. The first demands that learners are given opportunities for engagement and the invitation to invest themselves in the community of practice. This requires that they are able to build social relationships around meaningful learning activities. Additionally, education must include the imagination so that students are able to "explore who they are, who they are not, and who they could be" (p. 272). Imagination offers a way to expand a community's knowledge. Finally, they must include

educational alignment, engaging learners in activities that push boundaries and open up opportunities for new ways of being in the world.

Sociocultural conceptions of identity. "Because learning transforms who we are and what we can do, it is an experience of identity" (Wenger, 1998, p. 215). Notions of identity became central part of this study as I sought to understand teacher transformation, and I drew from a body of sociocultural perspectives on identity, each of which has slightly different characterizations of identity (Gee, 2000; Holland, et al., 1998; Sfard & Prusak, 2005; Wenger, 1998; Wortham, 2006). Gee (2000) refers to identity as being recognized as a certain kind of person. Holland et al. (1998) refer to identities as self understandings that are emotionally significant. Sfard and Prusak (2005) consider identity as a series of reified stories that one tells about oneself. Wortham (2006) suggests that individuals behave in certain ways or possess certain characteristics that identify them as a particular social type. Wenger (1998) argues that identity is a way of being in the world. These represent just a sampling of the scholars doing research on identity and demonstrate the range of ways that identity is understood and used. Though these perspectives are unique, they share common characteristics that position identity as socially influenced, continuous, multifaceted, and constituted through interpretations and narrations of experience (Luehmann, 2007).

Teachers' professional identities. Each of us has numerous identities based on our membership in various communities. To study one's identity is a deeply complex undertaking, and it would be impossible to address the whole complexity of each teacher's identity in this study. Therefore, I will concentrate only on one domain – teachers' professional identities, which has emerged as a subfield of sociocultural

conceptions of identity in educational research (Beijaard, Meijer, & Verloop, 2004; Luehmann, 2007; Volkmann & Anderson, 1998). Leuhmann (2007) argues that professional identity affords a lens to consider how experience impacts professional practices, values, beliefs and commitments. Thus, sociocultural conceptions of identity offer the field of teacher education a more inclusive construct that extends beyond what a teacher knows and believes. Beijaard et al. (2004) suggest that professional identity refers not only to what a teacher should know and do, but also includes what teachers consider essential in their professional work, based on their personal histories and experiences. Jurasaite-Harbison (2005) argues that the relationship between teacher growth, context and professional identity is not well-studied and needs researchers' attention. Consequently, research on teachers' professional identities can contribute to our understandings of the complexities of what it is like to be a teacher in today's schools.

In their review of the scholarship on teachers' professional identities, Beijaard et al. (2004) found that there is little consensus on what constitutes professional identity. In response, they identify the common characteristics that are essential in exploring teachers' professional identities. First, they establish that professional identity is an ongoing process of interpretation and reinterpretation of experiences. Essentially, teacher development is a process of life-long learning. Second, they posit that professional identity implies both person and context. Context has a profound impact on professional identity; thus, the two are interconnected. Third, professional identity consists of sub-identities, which are related to teachers' different contexts and relationships; Some sub-identities are at the core of professional identity while others are more peripheral. Fourth,

agency is critical to professional identity as teachers are actively involved in their own professional growth and development. From this perspective, teachers' professional identity is not just something teachers' have but something they actively construct to make sense of themselves as teachers. Thus, for the teacher, "identity formation is a process of practical knowledge-building characterized by an ongoing integration of what is individually and collectively seen as relevant to teaching" (Beijaard et al., p. 123).

Hall, Johnson, Juzwik, Wortham and Mosley (2010) explored the ways teachers use language to position themselves in their classrooms and develop their professional identities. They found that teachers do not construct their professional identities haphazardly but with intent. In so doing, they use language to position themselves or their students in specific kinds of ways. Volkmann and Anderson (1998) argue that professional identity is constituted in every aspect of teaching including teachers' knowledge of pedagogy, their knowledge of content, and their knowledge of teaching content. Furthermore, teachers aim to create professional identities that align with their personal identities. Therefore, professional identity is not accidental, but instead, is connected to history, the expectations of the schools where teachers work, to content knowledge, and to teachers' own vision of what it means to be a teacher. Coldron and Smith (1999) argue that being a teacher is a matter of being seen as a teacher and involves acquiring and then redefining a professional identity that is socially legitimated. They argue that for teachers, "some of their identity is born with them, some is achieved, and some is thrust upon them. An individual teacher's professional identity/location is, on the one hand, determined biographically, through his or her own choices, and, on the other hand, socially 'given'" (Coldron & Smith, p. 714). Moreover, teachers'

professional identities are brought to life in their classroom practices and in the ways they position themselves in their school communities.

Research specific to science education has found that science teachers perceive their professional identities to be intricately tied to their subject matter identity (Helms, 1998; Little, 1993; Talbert, 1995). From her research on secondary subject matter and teacher identity, Helms (1998) argues that science teachers feel a very personal identification with science and see themselves as part of both the science community and the education community. They have specific beliefs about what makes science exceptional and of value. Additionally, their discipline tends to be connected to other aspects of their lives. Therefore, science teachers construct identities that are in direct relation to science. She also suggests that teachers who closely identify with their subject matter often see teachers in other disciplines as fundamentally different. According to Enyedy, Goldberg, and Welsh (2006) a teacher's awareness of his or her identity as a science teacher is linked to his or her control over changing or adapting science teaching practices. In this way, identity can be used as a compass to help science teachers navigate teaching dilemmas. However, there is not much research exploring the ways science teachers obtain a sense of personal or professional identity from their subject matter (Helms, 1998). As a result, more research needs to be done to explore the ways teachers know themselves in relation to their discipline. Doing so, can inform researchers and teacher educators about a teacher's pedagogical choices and can improve efforts to provide meaningful PD.

Stories to live by. Connelly and Clandinin (1999), whose work explores teacher knowledge, developed the term "personal practical knowledge" to describe the

knowledge that is found in a teacher's practice. Teacher knowledge is formed and expressed in remarkably complex ways within school contexts, what Connelly and Clandinin (1999) call the "professional knowledge landscape" (p. 2). This professional knowledge landscape is not only complex but is also a storied landscape, one that is narratively constructed. Together, these terms, personal practical knowledge and professional knowledge landscape, were developed as a means to understanding teacher knowledge. As their work evolved, however, Connelly and Clandinin (1999) began to notice that teachers often focused on questions of identity and were more inclined "to ask questions of who they are than of what they know" (p. 3). In response, they coined the term "stories to live by" as the conceptual link connecting knowledge, context, and identity. These stories to live by convey identity and are "given meaning by the narrative understandings of knowledge and context. Stories to live by are shaped by such matters as secret teacher stories, sacred stories of schooling, and teachers' cover stories" (p. 4). Most teachers have multiple stories to live by that vary according to the different facets of their lives, and these "different facets, different identities, can show up, be reshaped and take on new life in different landscape settings" (p. 95). In this way, some stories to live by are developed and sustained as they are continuously reaffirmed over time. Others change and evolve in response to varying teaching contexts.

This study utilized Connelly and Clandinin's (1999) stories to live by to discern if and how teachers had been transformed. When a teacher's stories to live by are changed or evolve over time, it signifies an identity shift. When an identity shift is triggered by a specific learning experience, it can indicate that transformative learning has occurred. Hence, when used together, transformative learning theory and stories to live by, provide

a cogent, two dimensional lens for examining teacher transformation. Though transformative learning is seen as a change in the form of oneself, few scholars have joined transformative learning theory with sociocultural conceptions of identity. Pouriatine and Conners (2012) are an exception as they explored the role of identity in transformation. They found that transformative learning occurs when a process of fundamental change in identity is at work and often involves the renegotiation of oneself, where a new person emerges from the learning experience. This aligns with Kegan (1994) who suggests that transformation must encompass an actual remaking of the self and the way that that self knows the world.

This idea of professional identity and considerations of the ways teachers acquire and express their identities as teachers has serious implications for PD, particularly the way teachers are involved in and supported in PD efforts. Teachers' professional identities develop within the social, political and historical contexts in which they work, and thus, their PD is influenced by their personal motivation and initiative as well as by the wider context of their experiences (Swennen, Jones & Volman, 2010). In many ways, PD should be viewed as the development of teachers' professional identities. Doing so allows for a more personalized and contextualized understanding of teacher growth and change, and conceptualizes teacher learning as a continual process.

The Professional Development Landscape

Criteria for success. In considering the influence of participation in the SciJourn project on teachers, it is important to consider what we know about teacher learning and PD. According to Avalos (2011), teacher PD is a complex process, one that is "about teachers learning, learning how to learn, and transforming their knowledge into practice

for the benefit of their students' growth" (p. 10). Over the past twenty years, a significant body of research has emerged that considers the impact of PD on teachers and teaching and learning. This research has provided some clear guidelines regarding successful practices and the characteristics of high quality PD.

Supovitz and Turner (2000) argue that high quality PD: a) immerses participants in inquiry, questioning, and experimentation; b) is intensive and sustained; engages teachers in concrete tasks and is based on their experiences with students; c) focuses on content; d) is grounded in a common set of PD standards; e) is connected to other aspects of school change. In their evaluation of the Eisenhower PD program, Garet, Porter, Desimone, Birman and Yoon (2001) establish similar criteria. They found that sustained, intensive PD is more likely to influence teacher practice than shorter PD sessions. They also argue for PD that is focused on content rather than generalized instructional methods and suggest that involving teachers in active learning is more likely to result in enhanced knowledge and skills. Penuel, Sun, Frank, and Gallagher (2012) also argue for sustained PD and posit that frequent collegial interactions can enhance teacher learning. In their study on writing instruction, they found that teachers who interacted with colleagues who had changed their practice as a result of PD were more likely to change their own practice after having received help from those colleagues.

The National Writing Project (NWP) uses teacher collaboration as a central part of their training. Lieberman and Wood (2003) set out to explore the transformative properties of the NWP through an ethnographic analysis of six teacher participants. In their study, they found that the five key principles of the NWP are critical to its success. These principles are: universities and schools are better able to improve student learning

if they work in partnership; teachers are key to educational reform; teachers are the best teachers of teachers; writing deserves constant attention from kindergarten to the university; and exemplary teachers of writing are writers themselves. These key principles result in authentic learning experiences. The NWP fosters a specific kind of learning environment where teachers can engage with new tools and approaches on a particularly deep level. Teacher participants engage in a writing workshop where they write essays, stories, quick-writes, journal reflections and scholarly papers. This engagement in writing allows the teachers to reflect more genuinely on the process of writing, which, in turn, helps them to understand how to teach writing more effectively. The teachers and researchers also share their writings and instructional strategies while giving one another constructive feedback (Lieberman & Wood, 2003). According to Whitney (2008), writing activities in teacher PD give teachers the opportunity to grapple with issues of stance, authority, and identity. Garet et al. (2001) also suggest that producing written work requires a specific kind of active participation that allows teachers to delve more deeply into the learning process. Similarly, Bucynski and Hansen (2010) advocate for PD that mimics classroom implementation. They explored the impact of the Inquiry Learning Partnership (ILP) on science and math teachers' instructional practices and found that teachers valued the opportunity to experience learning activities from a student point of view as well as a teacher point of view. This authentic engagement in the learning process led teachers to make connections between the two perspectives and provided an enhanced opportunity for them to reflect on their teaching practices.

Putnam and Borko (2000) suggest that teachers need to have opportunities for PD outside of their local teaching context. They argue for summer institutes housed outside of schools, where teachers are free to learn without worrying about what they have to teach the next day. Thus, summer institutes can be powerful settings for teachers to develop new understandings regarding content and student learning. However, as teachers work to adapt their learning to their local situation, they need ongoing support throughout the school year. Therefore, a combined approach that includes both a summer institute as well as ongoing meetings throughout the year "holds the best promise for fostering powerful, multidimensional changes in teachers' thinking and practices" (Putnam & Borko, p. 7).

Buczynski and Hansen (2010) suggest that strong professional learning communities are central in promoting teacher learning and changes in instructional practices. Additionally, they suggest that meaningful learning for teachers is a slow and uncertain process, and some teachers are influenced more than others through participation in PD programs. Emphasis on community is a common thread throughout the research. McLaughlin and Talbert (1993) suggest that professional communities support the risk taking and struggle that goes along with transforming teaching practices. Additionally, professional communities bring together diverse groups of individuals with different knowledge and expertise and provide a forum where "community members can draw upon and incorporate each other's expertise to create rich conversations and new insights into teaching and learning" (Putnam & Borko, 2000, p. 7).

University and teacher partnerships. University and teacher partnerships can be viewed as expanded professional learning communities that bring together wider forms of

expertise. University participants bring with them research-based knowledge as well as the norms and modes of discourse that exist within the academic community. Teachers, on the other hand, bring knowledge about pedagogical practices and the realities of day to day teaching. In collaboration, these two realms can consider their practice in new and innovative ways while creating new forms of discourse about teaching and learning. In this way, projects become "joint productions" that enhance the understandings of all participants (Putnam and Borko, 2000). Successful collaboration is dependent on several factors. Engle (2010) identifies four principles for productive collaboration. These include: problematizing together, respecting everyone's authority, internal accountability, and sufficient resources. Collaboration between researchers and teachers can be particularly useful because they tap into different forms of expertise and different perspectives and apply these towards a common goal. This was evidenced in the Middle-School Mathematics through Applications Project (MMAP), a decade-long collaboration that led to the co-design of an innovative middle school mathematics curriculum. MMAP intentionally selected a diverse group of staff and teachers to broaden the expertise brought to the project. This diversity made it more likely that important issues would be problematized by the group and provided a richer learning environment (Engle, 2010).

By agreeing on shared norms and goals, community members can foster a culture of internal accountability where members grow to feel a sense of ownership over their shared work. In both the NWP and MMAP, the teachers get to choose how they will implement the project. Consequently, they get to make final decisions about which aspects of the project make it into their classrooms. In this way, teachers are encouraged to develop strategies that are tailored to their local context (Lieberman & Wood, 2003).

This flexibility works to cultivate accountability by allowing the participants to make the project their own. Rosebery and Puttick (1998) argue that teaching is complex, multidimensional and grounded in particular situations. They write, "On a daily basis, teachers grapple with the challenge of understanding individual students' thinking and of putting that thinking into productive contact with the ideas and practices of the discipline being studied" (Rosebery & Puttick, p. 650). Thus, skilled teaching is not only based on knowledge and practices but also on specific instructional circumstances. Because of particular circumstances, it is sometimes difficult to know how PD will be implemented or what exactly is going to be meaningful to the participants. Consequently, flexibility can be a critical component that influences a project's success.

Having sufficient resources is also critical. Resources not only include financial or material resources but also time and support (Engle, 2010). This is a particular area where day-long workshops fall short. In these workshops, teachers are trained on a set of tools and then expected to implement them. However, if something goes wrong or if they face a set of difficulties, there is no support system to help them problematize. Accordingly, they try a new strategy, it does not work, and they throw it out. The kinds of successful networks discussed here cultivate a non-threatening environment and provide a safe community that teachers can rely on for support when things do not come easily for them.

The notion of "inside" and "outside" knowledge is also important. Knowledge for teachers is typically "outside-in", meaning that it is generated at the university and then used in schools. An inside/outside model, however, privileges teachers as knowers. Cochran-Smith and Lytle (1993) argue that most of the research on teaching has left out

the voices of teachers, disenfranchising them from the research field. They suggest that the knowledge base for teaching should not only come from university-based research but also from research conducted by teachers, a model that positions teachers as "architects" of study and generators of knowledge. They define teacher research as systematic, intentional inquiry by teachers and argue that this kind of research provides a distinctive and important way of knowing about teaching because it arises from lived experiences. Similarly, based on her study of transformative learning in PD, Swanson (2010) argues that transformative PD must value the personal experiences, content, and pedagogical knowledge that teachers bring with them. She also suggests that transformative learning involves validating learners, situating learning within prior experiences, and viewing learning as mutually constructing knowledge. This is what Flint, Zisook, and Fisher (2011) refer to as "generative professional development," PD that positions teachers as individuals with specific needs and provides opportunities for reflection, growth, and engagement. As insiders, teachers have a unique perspective and their inquiries provide legitimate, valuable knowledge about teaching (Cochran-Smith & Lytle, 1993). Until such inquiry becomes an integral part of teaching, partnerships between universities and teachers can provide a community of shared authority where teachers actively participate in research and feel supported as they explore new approaches to teaching and learning.

This shared authority is evidenced in both the NWP and MMAP. In these programs, teachers are encouraged to contribute their own ideas on shared problems; their insights are valued and their voices are respectfully heard. Moreover, their feedback is esteemed and often reflected in later iterations of the work. These programs challenge the hierarchical model that often exists in researcher practitioner partnerships

by positioning teacher knowledge at the center. In this way, their authority becomes essential to the collaboration. Coburn and Stein (2010) found that the most successful university and teacher partnerships involved teachers in their design efforts. Practitioners bring with them a specific knowledge about what is feasible and practical in the real world of classrooms. Involving them in research-based designs helps ensure that these designs are used.

Design research. In traditional research models, design and research are distinct processes. Design research, however, is characterized by repeated cycles of design, enactment, analysis, and then redesign. In this way, each implementation of a project is used to inform subsequent designs and the line between research and design is blurred (Edelson, 2002). In design research projects, research is used to generate ideas around practical problems and theory is continually being constructed through the iterative cycles of design and implementation. Penuel, Fishman, Cheng, and Sabelli (2011) suggest that this kind of research is often used to develop and test tools for improving teaching and learning in specific content areas. They argue for design-based implementation research, which focuses on designing sustainable improvements in teaching and learning. This necessarily includes establishing routines and processes that enhance programmatic scalability. Additionally, design-based implementation research is concerned with the adaptations that are required for implementing projects in new and various sites. Weinbaum and Supovitz (2010) suggest that the implementation of reform efforts is an uncertain process. They argue that decades of research shows that even the most clearly articulated programs are unlikely to be implemented with "fidelity" and improvement programs are often used in unexpected and inconsistent ways. They

theorize implementation as a process of iterative refraction, where reform efforts undergo various revisions as they make their way into schools. Mehan, Hubbard and Datnow (2010) refer to this as a "co-construction" process, using the analogy of "building the plane while flying it" (p. 105). They argue that teachers do not passively implement reform projects, but rather, they construct teaching in the moment. "Educators modify reform design features in various ways to fit with sociopolitical and cultural factors, their local needs, practical circumstances, and their own ideologies. In some cases, reform implementation is enhanced. In other cases, it is constricted" (Mehan, et al., p. 109).

Much of the research on PD has offered clear insights into what constitutes a productive PD experience. However, Buczynski and Hansen (2010) argue that there is still much work to do and many questions to answer regarding how we can provide high quality PD to all teachers. They suggest that there is a need for many different kinds of inquiries and research tools to develop the rich understanding that is necessary to accomplish this goal.

Summary

This chapter explored the conceptual frameworks that were used throughout the study and also delved into the current body of research investigating teacher PD. As a growing field of study, there is still much to be learned about how teachers change their instructional practices and how professional learning experiences can be intentionally designed to facilitate transformation. This study adds to this body of research by exploring teacher transformation within a particular educational reform network. The work presented here also contributes to a body of research that seeks to refine transformative learning theory by integrating the theory with additional conceptual

frameworks. In so doing, this study ascertains which features of the theory are most salient when applied to this particular learning experience.

Chapter 3: Methods

This study focused on teachers' experiences with the SciJourn project and the ways their knowledge, professional identities and classroom practices were influenced through their participation in the project. Thus, I utilized a qualitative, multiple case study design using a phenomenological approach to interviewing as my primary data source. I also employed the tools of narrative inquiry in an attempt to preserve the voices of my participants.

Creswell (2007) describes the case study as a qualitative approach with a case or cases situated within a single setting or context and explored "through detailed, in-depth data collection involving multiple sources of information" (p. 73). Here, I have adopted a multiple-case study design where I first present each participant's story followed by individual analysis and then a cross-case analysis.

In this chapter, I begin by reviewing the research questions presented in chapter one. I then discuss epistemology and my decisions to draw on the tools of narrative inquiry while using a multiple case-study. Next, I describe the methodology I used in the study including: results from a pilot study, using a survey to determine case selection, design of the phenomenological interviews, data analysis and interpretation, consent procedures and confidentiality, trustworthiness, and limitations of the research.

Overview and Research Questions

This qualitative study draws heavily on phenomenological interviewing techniques (Seidman, 2012). Phenomenology is grounded in the work of the German philosopher, Edmund Husserl (1859 – 1938). Based on Husserl and Gibson (1931), phenomenological research seeks to describe rather than explain and does not begin with

hypotheses or preconceptions. The word *describe* is critical. Essentially, the researcher seeks to describe as accurately as possible the phenomenon, refraining from any preconceived ideas and remaining true to the facts. Husserl's philosophy of phenomenology provided a point of departure for Alfred Schutz, who writes that the phenomenological perspective is one where we seek our participants' subjective point of view (1988). For the phenomenologist, the experience itself is of interest. According to Patton (2002), the defining characteristic of phenomenology is the assumption of essence, which represents the core meanings mutually understood through a common experience. In this context, my research sought to understand the essence of science teachers' experiences as participants in the SciJourn project. Thus, the following research questions guide this project:

- How did the SciJourn project build professional community and influence transformative learning?
- How did participation in the SciJourn project influence science teachers' professional identities, knowledge, and classroom practices?
- In what ways were teachers transformed?
- Why were some teachers transformed by their participation in the project, while others were not?

Epistemology and Methodological Choice

In this study, I have adopted an interpretative constructivist position that prioritizes individuals' experiences and stories. In line with my epistemological choice, I have employed the tools of narrative inquiry and applied them to multiple cases. Clandinin and Rosiek (2007) write that the most defining feature of narrative inquiry is

the study of experience as it is lived. As such, Connelly and Clandinin (2006) write that narrative inquiries do not take specific forms but rather embody particular qualities and attend to three "commonplaces": temporality, sociality, and place. Temporality refers to the narrative inquirer's awareness of the temporal nature of events, people, and objects under study, acknowledging that all experience has a past, present, and a future. This notion of temporality is important to this study as participants shared their teaching histories, the decisions they have made and the influence these have had on their teaching identities.

Sociality refers to both the personal and social conditions that are part of an individual's story. Connelly and Clandinin (2006) write that sociality includes social factors, people, and environment, as well as an individual's internal thoughts and feelings. A narrative inquiry is concerned with both of these dimensions of sociality. In this investigation, context was an important piece as the teachers shared their personal thoughts and feelings in relation to their particular teaching situations and individual needs. The third "commonplace," place, refers to the physical, concrete space where a narrative inquiry occurs. As such, narrative inquirers attend carefully to the importance of place and its influence on study participants.

Here, I have employed a multiple case study design. Case study research is well-suited for studies that seek to explain how or why a phenomenon works and is particularly useful for studies that require an in-depth description of an experience (Yin, 2014). Furthermore, the investigation focuses on a phenomenon that is intrinsically bounded. Case studies are appropriate when the researcher is concerned with understanding the context of a phenomenon and interested in "insight, discovery, and

interpretation" (Merriam, 2009, p. 42). Thus, a case study design was well-matched to my research questions as I was interested in each teacher's experiences with the SciJourn project and the ways participation in the project was or was not transformational. I chose a multiple case study design because I was interested in comparing teachers' experiences and sought to uncover a set of "cross case" conclusions (Yin, 2014).

Pilot Study

In the summer of 2012, I conducted a pilot study as a means to refine both my research questions and my methodology. It was obvious that I needed to start by talking to the teachers involved in the project, and interviews seemed like a logical place to begin. I also had access to drawings that the teachers did during a PD workshop during the second year. These drawings represented their experience with SciJourn and seemed to provide a good starting point for my conversations with them.

From there, I (perhaps prematurely) developed a protocol of open-ended questions that sought to elicit thorough responses (Appendix A). I should have been able to articulate exactly what kinds of responses I was looking for, but at the time and in truth, I didn't have a clue. As a naïve graduate student, I was pretty intent on starting the research process though I had not focused my ideas.

With protocol in hand, I decided to test it out and interview a teacher. I chose Cynthia[1], a teacher from the first cohort, because she had shown success with the project and was always enthusiastic about sharing her experiences. Not surprisingly, she was more than happy to participate. So, on a hot, Monday afternoon in July, I went to her home. As we sat down to talk in her living room, we were joined by two, welcoming basset hounds who sat at our feet. The interview went well. Cynthia was very warm and

[1] All names are pseudonyms

open and gave me numerous thoughtful responses. I came away feeling good about the experience. That feeling lasted for about two days until I sat down to transcribe our conversation. It was then that I started to see clearly that my entire approach needed to be revised. Although Cynthia gave me some interesting insights into the way she implemented SciJourn and the choices that she made, her responses did not necessarily tell me *why* she made those choices. Overall, her responses remained at a very surface level. Take the following excerpt for example:

> MW: So why did you choose to implement it in the way that you did?
>
> Teacher 020: I think it's just my style of teaching.
>
> MW: Ok
>
> Teacher 020: Um, like I said, I'm not a lesson person. You know. I mean I think the lessons that are planned out are good but I don't teach that way. You know. We, a few, a number of years ago, we had those, you know canned lessons in a box.
>
> MW: Oh yeah
>
> Teacher 020: And I can't do those. You know, I was like, it's not me. My style is kind of like free flowing, I don't know, let's try this, let's do that so I just kind of let the kids direct it so I might say, "let's talk about topics" and I don't really do the lesson on topics. "Let's talk about um titles, ledes. What do you think a lede is?" or they read the ledes in there. So I'm not really a follow someone else's lesson, I'm a do it myself type person.

Here, Cynthia's response gave me some sense of her choices. She did not typically use SciJourn's lessons because it was not her style. However, I did not really have a sense of

what her style was, or why she was a "do it herself" type person. Ideally, I would have followed up with a question that would have evoked a deeper response, but instead, I just moved the interview along, to get through my protocol.

In order to really understand Cynthia's decisions, I needed to somehow go deeper. Seidman (2012) refers to this as getting to the language of the "inner voice". During interviews, participants tend to use their outer, public voice, showing their awareness of their audience. It is in the language of the inner voice, however, where we will find the most thoughtful responses. If I wanted to go deeper in my interviews, then I needed to find access to the teacher's inner voice. This meant approaching the interviews and asking questions in an entirely different kind of way.

Refining my interviewing technique also required that I reassess my role as an interviewer. During Cynthia's interview, I missed out on numerous opportunities to ask her to expand on her responses because I was tied to my protocol. Essentially, I was a poor listener and distracted by my own agenda. I also felt the need to reinforce and agree with her ideas, a seemingly harmless act, but one that could have unintentionally influenced how she responded. Moving forward, I needed to be more aware of showing that I was listening without articulating agreement. I also needed to allow several moments to pass after the participant had finished a thought rather than jumping right into the next question. Silences are not necessarily bad. In fact, Mears (2009) argues that "there are messages and perhaps cultural significance in the silence of the unspoken word and in the cadence of memory" (p. 117). Consequently, as an interviewer, I needed to be more patient and focus more intently on listening to my respondent's cues. Seidman (2012) suggests that interviewers need to listen on three different levels. First, they must

listen to what a respondent is saying to determine if the response is as detailed and complete as they would like it to be. Second, they must listen for the "inner voice", which evokes a deeper level of thoughtfulness. Third, they must listen so they can assess the progress of the interview and stay alert for clues about how to move the interview forward. In order to engage more deeply as a listener, Seidman (2012) encourages interviewers to take notes during the interview. This can be helpful for concentrating on the responses and avoiding reinforcing comments. As I moved forward with my research, I was aware that I needed to pay closer attention to my own role as a researcher, and I also needed to be much more deliberate in how I listened to and engaged with my respondents.

When I initially decided to use interviews for my research, it never occurred to me that I might need to interview the teachers multiple times. The overly enthusiastic graduate student in me just wanted to do some research! I guilelessly figured that if I could interview three to five teachers right away, I would have a good start and be well on my way to my dissertation. After Cynthia's interview, it became clear that if I really wanted to understand her experience, I would need to have a better sense of who she is as a person and a teacher. It is impossible to understand someone's story without having some context for who that person is. Mears (2009) argues that in the first telling of an experience, people often recount the same stories they've told over and over again, and these stories are unlikely to lead to a deep understanding. Since my intention for using interviews was to get inside the teachers' experiences, this required a more complex interview process, but first, I had to select my participants.

Surveying the Landscape

As a starting point for my data collection, I developed a survey, which I used to categorize SciJourn teachers into three levels of influence: significantly influenced, moderately influenced, and slightly influenced (Appendix B). The overarching goal of the survey was two-fold. I wanted to map the broad landscape of the project's influence on teachers and also to identify teacher participants for my interviews. From the start, I knew that the essence of my data would come from in-depth interviews and the survey would simply serve as the point of departure.

Survey Design. The survey was developed as an electronic, web-based instrument and included three types of questions: informational questions, Likert questions (closed questions on a continuum), and free response (open) questions. Because I intended to use the survey to select teacher participants, it was not anonymous. Some of the Likert questions and free response questions were intentionally similar, designed to assess the consistency of teachers' responses. In the original draft of the survey, the informational questions were followed by the free response questions, which were followed by the Likert questions. To assess validity, I shared the first draft of the survey with the SciJourn research team to check for clarity and gather input on the order and phrasing of the questions. One of the researchers suggested that I move the Likert questions before the free response questions. She suggested that the Likert questions might stimulate teachers' thinking as they moved into the free response questions. I took her advice and rearranged the order in the final draft.

The survey was implemented electronically using Qualtrics Research Suite, an online survey tool. Thirty-two SciJourn teachers, who had gone through one of the

summer training sessions, were sent an email inviting them to participate in the survey via a hyperlink. To increase response rates, the 16 teachers who attended SciJourn's final teacher meeting and celebration on May 9, 2013 were given time in the meeting to complete the survey on laptops. The final data set included responses from 28 teachers.

Analysis of Survey Responses. I began the analysis of the surveys by reading through each survey individually to get a general overview of the responses. I then went back and read them a second time, making note of the general themes (Lincoln & Guba, 1985). In so doing, I began to notice some contradictions in individual responses, particularly between the Likert questions and the free response items. Specifically, the majority of teachers marked that they were significantly influenced for all of the items (Table 1), yet, when I compared their responses to the free response items, they did not necessarily align. For instance, one teacher, who noted on the first Likert question that SciJourn had a significant influence on how he thinks about science literacy, answered the same free response question by writing, "I have always had science literacy as a main focus in my teaching and educational philosophy." These differences in responses raised questions for me as I tried to make sense of the data, and the three levels of influence that I had identified seemed unreliable as a method for categorizing the teachers.

After grappling with the data for a couple of weeks, I decided to put the Likert questions aside and look solely at the written responses. As I read and re-read, I saw some clear themes emerging and began to code the responses. After several rounds, my codes were sorted into categories (described below), which eventually led me back to my original three levels of influence. Though there was some crossover in responses (for instance, read-aloud/think-alouds were mentioned by almost every teacher), I tried to

make the following categories exclusive by requiring that the teachers' responses matched at least two of the themes present in that category.

Table 1

Teacher Responses to Likert Questions

#	Survey question	Not at all	Slightly	Moderately	Significantly	Total responses
1	SciJourn has influenced how I think about science	0	1	2	25	28
2	SciJourn has impacted how I think about science	0	1	3	24	28
3	SciJourn has influenced my teaching goals	1	0	8	19	28
4	SciJourn has influenced my instructional practices	0	2	8	18	28
5	SciJourn has impacted my teaching philosophy	0	3	8	17	28
6	SciJourn has influenced how I engage with my	0	2	6	20	28

Significantly influenced. Teachers in this category expressed a dramatic shift in their thinking as a result of SciJourn. This shift in thinking then led to significant changes in their instructional practices. Teachers in this category gave extensive written responses and expressed at least two of the following themes in their responses:

- A strong connection with SciJourn's definition of science literacy
- A major change in how writing is incorporated into their classes

- Ongoing implementation of the project
- Adapting the project and making it their own
- Noticeable increase in student engagement
- SciJourn ideas and concepts have become a part of who they are as a teacher
- Re-prioritizing what they include in their curriculum based on what they learned and experienced in SciJourn
- A dramatic change in teaching style

One teacher in this category in response to question 10, for instance, explained how SciJourn's definition of science literacy influenced his instructional practices. He wrote:

> I really like the idea of what students will need to know or do 15 years after graduating from high school. This idea is in the back of my mind when I create lessons. I focus more on the skills and critical thinking than I ever did before.

Another teacher, in response to question 11, which asked what elements of SciJourn teachers might still be using in their instruction five years from now, expressed that SciJourn has become a critical part of her teaching. She wrote, "I want my own Environmental newspaper in my classroom. Read-alouds, student-centered topics. It is fundamentally ingrained in my teaching." In response to question 12, which asked what was most influential about the project, another teacher in this category emphasized the impact of the project on student engagement. She wrote:

> That students love to investigate subjects of their own choosing. Give them a vehicle to research an interesting topic, give them a real audience, provide a place to showcase their work and they will revise, edit, revise, rewrite until they accomplish their goal.

Moderately influenced. Teachers in this category indicated that SciJourn had a clear influence on their teaching practices, but they did not express a shift in thinking. Though generally positive, their responses tended to be briefer. They expressed at least two of the following themes in their responses:

- Finding the tools of SciJourn to be useful
- More class time devoted to writing
- More class time devoted to researching
- More emphasis on multiple and credible sources of information
- Inclusion of infographics
- Using read-aloud/think-alouds regularly
- Implementation has decreased because of other curricular obligations
- A desire to do more SciJourn activities in the future

One teacher in this category, for example, responded to question 10, explaining the influence of the program on her instructional practices, by writing, "I have included more writing in my lessons than before SciJourn." Another teacher responded to the same question by writing, "I do many more read-aloud/think-alouds." In response to question 12, which asked teachers what was most influential about the project, a teacher in this category wrote, "Teaching students how to look for and cite multiple, credible experts."

Slightly influenced. Teachers in this category expressed a general appreciation for the project but did not indicate any clear influence on their teaching practices or a shift in their thinking. Their responses were brief or vague, and many of them skipped questions. Teachers in this category expressed at least two of the following themes in their responses:

- Implementation was never strong
- Indicated specific barriers to implementation
- Implementation has decreased significantly
- Still use read-aloud/think-alouds occasionally
- Wanting to implement more but not sure how
- A desire for more PD tailored to teachers who were struggling to implement or who needed more support

A teacher in this category, for instance, responded to question 10, regarding the, project's influence on instructional practices by writing, "Very little." Similarly, another teacher answered the same question by writing "Use computers more." Another teacher answered question nine, which asks about the influence of the project on the teacher's understanding of science literacy, by writing, "Definition and practice."

Case selection. Based on my analysis, 10 teachers were in the significantly influenced category, 10 teachers were in the moderately influenced category, and eight teachers were in the slightly influenced category. From there, I used purposeful sampling and chose nine potential teachers (three from each category) to interview (Glaser, 1978). I intentionally selected teachers who had not been interviewed by other researchers because I wanted to hear new stories. I was also mindful of choosing participants from different backgrounds and different teaching contexts. For the significantly influenced and moderately influenced categories, I had difficulties narrowing my selections down to three potential participants because I had so many who gave rich and interesting responses. Ultimately, the participants I chose in these categories were the ones who responded quickly and whose schedules allowed for three extensive interviews.

Choosing participants from the slightly influenced category proved a bit more problematic because two of the most interesting cases did not want to be interviewed. Additionally, many of the responses in this category were vague or brief or even missing, which did not give me much insight into the teachers' perceptions. I chose two potential participants from this category, both of whom had articulated clear criticisms of the project. Overall, criticisms were very rare in the survey responses, so I was interested in learning more.

In the end, I selected and interviewed two teachers from the significantly influenced category, one teacher from the moderately influenced category, and one teacher from the slightly influenced category. I also interviewed a teacher who did not attend SciJourn's summer workshop but rather, found and implemented the project on her own. Each of these cases are introduced in chapter five.

Usefulness of the Survey. As previously mentioned, the survey was used as a point of departure for my interviews. Essentially, the survey was designed to give me a snapshot of teachers' perceptions of the SciJourn project and to provide a methodical approach for case selection. In that regard, the survey served its purpose. That is not to say, however, that the survey was without flaws.

Since survey responses were not anonymous, some respondents might not have been forthcoming with their answers and may have inaccurately reported their impressions. Robson (2002) refers to this as "social desirability response bias", wherein people respond so that they are viewed in a positive light. If I were giving the survey as my primary means of data collection, I would certainly want to make it anonymous to

help decrease such bias. However, in this case, an anonymous survey would have been useless as a tool used to select participants.

In his book, *Survey Research Methods,* Fowler (2009) argues that closed questions, which give respondents a list of acceptable responses, are more reliable for analyzing and interpreting meaning. He suggests that when respondents are asked to place themselves on a continuum the only assumption that is necessary for a meaningful analysis is that those who respond on one end of the continuum, on average, feel more positively than those on the other end of the continuum. Based on my survey results, I respectfully disagree. While the Likert questions did give a snapshot of where the teachers saw their level of influence, it was obvious that there were different understandings or perceptions about what the categories meant, which muddled my analysis. To this end, Robson (2002) suggests that surveys work best when researchers are certain that standardized questions mean the same thing to different respondents, which is difficult to know in exploratory research. In my case, however, it was not until I set the Likert questions aside that I was able to make sense of the data. In short, I could never have designed a closed survey that would have captured the richness or diversity that the free response questions provided. While the Likert responses were not useful for categorizing the teachers, it is possible that those questions influenced the teachers to write more in the free response questions. Perhaps the Likert questions got the wheels turning or it's possible that the Likert questions did not express the respondents' feelings accurately so they wrote more extensive explanations. If I were to do it again, I would likely keep the Likert questions, but I would not focus on those responses in the analysis. I would also include a few more questions designed to tease out more details. In

hindsight, I see that my questions were framed positively, emphasizing the beneficial qualities of the project. It would have been helpful to have more insights into which aspects of the project were not influential and what caused the teachers difficulties in their implementation. For instance, I would likely add a question that asked specifically about what aspects of the project were not influential. Additionally, I would ask what barriers the teachers encountered in their implementation of the project and how those barriers were, or were not, overcome. Ideally, these questions would elicit more criticisms and give greater insights into the weaknesses of the project.

Surveys certainly have their place in the research landscape. Yet, if the goal is a deeper, more interpretative analysis, then there are significant limitations in what survey data can tell us. The metaphor of a backpacker comes to mind. Before embarking on a hike, the backpacker spends time poring over maps, learning the terrain, and plotting a specific course. But it is not until the actual journey, where the backpacker gets to experience the terrain underfoot, that he or she can truly understand it and make fully informed decisions. Much like the backpacker reading a map, the survey gave me a general idea of the landscape of SciJourn's influence on teachers, but if I wanted to gain significant insights into the teachers' experiences, it was imperative that I explore the terrain in more detail.

Phenomenological interviews

Based on what I had learned from my pilot study, I chose to interview each teacher three different times. This idea was based on Seidman's (1991)[2] three-interview series which arose from his idea that people's experiences are only understandable when placed in the context of their lives and the lives of those around them. Without context, it

[2] Originally published in 1991, Seidman's text is now in its fourth edition (2012).

is impossible to explore meaning in any depth. In Seidman's series, the first interview focuses on life history, where the participant tells about his or her past life up until the present time. The second interview concentrates on the concrete details of the participant's present experiences as related to the topic of study. In the third interview, the participant reflects on his or her experiences. Together, these three interviews build on one another allowing for reflection on the past, as well as the present situation. The three interview structure that I used was loosely based on Seidman's framework.

I established these interviews as an invitation for the participants to tell me *their* stories. I used questions and prompts that gave the teachers the opportunity to think aloud about their experiences. In doing so, I let my respondents talk freely about what they considered to be important. In my pilot interview with Cynthia, I felt tied to my protocol. Consequently, I redesigned my protocol to include questions and topics (Appendix C). For each interview, I began with a question as a starting point, establishing the territory to be explored. From there, I let the interview flow in a manner that made sense to the interviewee. By actively listening, I was able to guide the interviews through the use of appropriate follow-up questions while still allowing the participant to talk freely about what he or she determined to be relevant. At the end of each interview, I also gave the respondents the opportunity to add anything that they felt was important or worthy of being included. I then asked them to consider related topics or ideas to bring to the next interview and encouraged them to email me with any further reflections they may have had. Each interview was audio recorded, and I wrote reflective memos after each interview to document my impressions and my ideas for improving the interview process.

The first interview. The first interview was used to help me gain an understanding of who the teachers are. Specifically, I was interested in their professional identities. My hope for this interview was that it would provide the context that was necessary for me to really understand each teacher's experience. The primary question that guided this interview was: "How did you become a science teacher?" I then asked follow-up questions based on each teacher's responses. These were the topics that I hoped would emerge from this interview:

- Meaningful experiences that led to an interest in science
- Meaningful experiences that led to an interest in education
- Other careers before teaching or careers that were considered
- Professional identity (strengths and weaknesses)
- Context of local teaching environment
- PD experiences (prior to SciJourn)

The second interview. The second interview was used to explore the teachers' experiences with SciJourn. The intention of this interview was to gather insights into their perceptions of the PD sessions and their implementation of the project. The initial prompt that focused this interview was: "Tell me about your experience with SciJourn." Topics that I wanted to cover in this interview were:

- Perceptions of the PD sessions
- Implementation (past and present)
- Challenges and successes with the project
- Stories about classroom experiences
- Reasons for participating in SciJourn

The third interview. This interview gave the teachers an opportunity to reflect on their experiences with SciJourn, its long-term effects, and whatever they felt was important to share about their journey with the project. Essentially, I wanted to know what the project meant to the teachers. The prompt that guided this interview was: "What, if anything, did you take away from your participation in the SciJourn project?" I then concluded this interview by using a strategy designed by Mears' (2009). She suggests that at the end of the final interview, researchers should remind their participants that they cannot include all of their stories or experiences in the analysis. It is useful then to ask the participant for guidance, something along the lines of "What stories or points are the most important to include?" This gives the respondents the opportunity to reinforce what they believe to be important, while also giving them a final sense of authority. The topics that I hoped would emerge from this interview were:

- Influential qualities of the project
- Future implementation
- Impact on teaching philosophy and beliefs about teaching
- Impact on classroom practices
- Influence on professional identity

Ultimately, my research agenda was not what was most important, but rather, it was the participants' individual stories and experiences that had the most value. "Entering into an interview relationship with another is made easier if you operate in the role of an interested guest, one who seeks the opportunity to learn and appreciates the narrator's role as the host or guide who holds the experienced perspective that you need" (Mears, 2009, p. 101). Throughout the process, I used this guest metaphor to guide my

interview research in hopes that it would lead me to a deeper understanding of the teachers' experiences.

Interviewing myself. As a former teacher participant in SciJourn, I also turned the lens on myself. By exercising this reflexivity, I hoped to generate a deeper understanding of my own subjective connections to the research. To do so, I had another researcher interview me using the same protocol that I used for the teacher participants. We conducted these interviews before any of the teacher interviews. Doing so allowed me to assess the phrasing of the questions. It also gave me some insights into how my participants might feel during the interviews. This proved to be useful. The original prompt that I had planned to use for the third interview was: "Describe what it was like to be a part of the SciJourn project." However, when I was asked that question by my fellow researcher, I found it difficult to answer. Afterwards, I wrote the following in my research memo:

> Today Nicolle and I had the final interview. I'm really not happy with the way this interview went. During the interview, I was supposed to reflect on my experience with SciJourn and the project's influence on me. However, the prompt that I wrote "Describe what it's like to be a part of the SciJourn project" just didn't work. After Nicolle gave me the prompt, I should have stopped the interview because the prompt isn't good. I actually paused for quite awhile as I contemplated this on the recording. Nonetheless, I knew what topics I wanted covered so I was able to touch on most of them but definitely was not as articulate as I would have liked to have been. I'm also not sure that I went into the level of

> detail that I would hope to get from my participants (Researcher Memo, 7-8-2013).

Based on that experience, I revised the third interview prompt to focus more specifically on the ways the teachers were influenced by the project.

Interview with two of the project developers. As I explored the ways SciJourn was designed to facilitate community and collaboration, it was important to include the voices of the individuals who designed the project as well as the teacher PD. To do so, I held a team interview with two of the developers of the project. One of these researchers, Wendy Saul, was the primary PD designer for the project. Saul has a Ph.D. in education and has worked extensively to explore the relationship between science and literacy. The other researcher, Alan Newman, worked as the project's news editor. He has a Ph.D. in chemistry and worked for 18 years as an editor for the American Chemical Society. I developed the protocol (see Appendix D) and conducted this interview after I had analyzed the interviews with the teachers so I could bring those insights to the conversation. The purpose of this interview was to reveal the designers' collective viewpoint regarding the planning of the PD, how they worked to build community, how the project evolved over time, as well as their impressions of the teacher participants and their experiences.

Data Analysis

All of the interviews were transcribed using a professional transcription company. To ensure accuracy, once I received the transcripts, I read through them carefully while listening to each audio recording, making changes when necessary. From there, the data analysis took place in three separate phases, which are described below. Throughout the

study, my data analysis was a highly inductive process where I let the data tell the story. To authenticate my findings, I wrote researcher memos, kept a research journal, and also maintained an audit trail of my decisions and interpretations throughout the process.

Phase one. The first phase of data analysis was a two step process that focused on the three, phenomenological interviews held with each of the teachers. During this phase, I drew on the tools of grounded theory and began with an open coding process to identify reoccurring themes in each of the teachers' stories (Corbin & Strauss, 1990). During this stage of the analysis, I looked specifically for insights into the influential qualities of the project while developing a preliminary codebook. I made multiple passes through each interview and used axial coding to group and collapse these codes into stable categories (Corbin & Strauss, 1990; Merriam, 2009) (see Appendix E for the complete and final codebook). The second stage of the analysis was a second round of coding using Mezirow's (2000) ten phases of transformation as an entry point. During this stage, I read through the interviews looking only for evidence of transformative learning and these ten phases. Once again, I went through each interview several times. To ensure that my codes were clear, I had two researchers code two interviews using my codebook. When there were discrepancies, I returned to the codes and redefined them to ensure they were stable.

Phase two. Phase two of my analysis focused on the interview that was conducted with two of the researchers who developed the project. The data analysis for this phase also occurred in two stages. The first stage began as I was analyzing the teachers' interviews. As reoccurring themes began to emerge in the teachers' stories, I started to attend more closely to the teachers' perceptions of science literacy and the ways

SciJourn influenced these perceptions. From there, I decided that it would be necessary to take a closer look at the process of critical reflection and how it emerged for these teachers during the project. This required that I gain clearer insights into the history of SciJourn's definition of science literacy and learn the story of how it came to be. Similarly, I felt that it was necessary to get the insider perspective on the ways the PD was designed and how it evolved throughout the project. Therefore, these became important topics as I developed the interview protocol.

The second stage of the analysis involved coding the interview with the researchers. During this process, data was analyzed using an approach most often associated with grounded theory. Data were deconstructed into codes that came from discrete incidents and ideas (Strauss and Corbin, 2008). Some of these concepts included "in vivo codes" that developed directly from quotations from the transcripts (Glaser & Strauss, 1967). I then used axial coding to group these initial codes and collapsed them into stable categories (Corbin & Strauss, 2008) (see Appendix F for the final codebook).

Phase three. The third and final phase of my data analysis called for a closer comparison between two of the teachers' stories. This phase also had two stages. During the first stage, I returned to the original transcripts of my interviews with these two teachers and conducted a close narrative analysis. "Narrative inquiry seeks to understand, not critique" (Craig & Huber, 2007, p. 272). As I sought to understand why these two teacher's experiences were so different, I looked for moments of tension in their stories. From there, I began to identify notable differences in their experiences and generated a list of codes. Once I had these codes, I returned to the transcripts and worked

to condense these codes into stable categories. From there, two primary tensions emerged that were representative of their difference experiences.

Once I completed this initial stage of the analysis, I returned, once again, to the transcripts. While the easiest way to reduce interview data to a manageable size is to summarize what I have heard, doing so risks losing the narrator's voice (Mears, 2009). For this close examination of these two teachers' stories, preserving their voices was particularly important as I attended to the subtle differences in their experiences. Therefore, to reduce my interview data, I used a technique drawn from narrative analysis and used poetic transcription to create excerpted narratives to tell the story that helped to answer my research questions. To do so, I went back to my coded transcripts and pulled excerpts that I had marked as representing each of the major themes. I then compiled these excerpts together (see Appendix G). From these excerpts, I then created two, separate poetic representations for each teacher that were representative of their diverging experiences with the project. Lawrence-Lightfoot and Davis (1997) suggest that narratives offer a way to record the subtle details of experience while preserving the nuances and complexities. Thus, the purpose of this kind of poetic, narrative display was to preserve the meaning of my speakers, while bringing the raw data to life to illuminate their experiences.

The coding process described above played a crucial role in this process as it allowed me to sort through the data and identify patterns representative of experience. Riessman (1993) suggests that the researcher pay close attention to the structure of narratives, looking closely at the ways the story is organized, exploring why the speaker develops his or her tale in such a way. Doing so allowed me to unpack each teacher's

story. It was both an iterative and generative process, one of description, interpretation, analysis, and synthesis where the researcher "draws out the refrains and patterns and creates a thematic framework for the construction of narrative" (Lawrence-Lightfoot & Davis, 1997, p. 185). In this way, I scrutinized the data searching for the story to emerge. It was both a careful and deliberate process (Lawrence-Lightfoot & Davis, 1997). According to Mears (2009), displaying data in this kind of narrative form is visually powerful. Paragraphing draws our attention to structure and grammatical characteristics. A narrative display, similar to a poem, focuses the reader's attention directly to the message that is being conveyed. The poetic representations presented here captured what I perceived to be the essence of the two teacher's stories, with particular emphasis on the ways their experiences with the project differed. While these poetic narratives represent my interpretations, the words came directly from the transcripts. I also maintained the chronological order of the excerpts to preserve the storyline presented by each speaker.

Reissman (1993) argues that narrative analysis is well-suited to studies of subjectivity and identity. Merriam and Kim (2012) argue that people's stories are rich resources for accessing the depth of transformative learning. Consequently, this kind of narrative analysis can be particularly useful when using transformative learning theory as it relies heavily on the text of the story, allowing people's stories to emerge as they make meaning through language. Essentially, these excerpted narratives presented critical elements of these teachers' stories delivered through their own words. They provided content to help answer my research questions and communicated in ways that helped to cultivate a rich understanding of these two teachers' particular experiences.

Consent and Confidentiality

Each participant was given a consent form in accordance with the University of Missouri - St. Louis' Institutional Review Board requirements (Appendix H). I discussed the design of the study with each participant and explained that the interviews would be my primary method of data collection. I also explained to them the time commitment involved and requested permission to audio record each interview. We discussed how the interview data would be used, and I assured them that I would maintain their confidentiality by using pseudonyms. Additionally, each participant was informed that he or she could choose to withdraw from the study at anytime without consequence.

Researcher Role and Reflexivity

I have an insider perspective as a previous teacher participant with the SciJourn project. I consider my insider perspective an asset to this research because it afforded me the unique opportunity of knowing the reality of implementing SciJourn in a classroom. When I interviewed teachers, I was not just a researcher on the outside, but a former colleague, someone who had been in the trenches with them, so to speak. I could personally relate to both their challenges and their successes. I previously attended a workshop on interviewing that was led by Dr. Seidman on March 7, 2013. During that workshop, he reminded us that "interviewing is a privilege" and we must be careful with people's words and how we use them. This brings me back to the guest metaphor used by Mears (2009). As an invited guest, I sought to preserve the vibrancy of the teachers' stories and to create a richly tapestried account of their experiences. Having said that, I acknowledge the importance of making clear how my own biases and assumptions affected my research, which is why I turned the analytical lens on myself. I sought to be

reflective about my positioning with the project and to consider the ways my experience was similar to or different from the other participants.

Trustworthiness

Firestone (1987) states that even though qualitative researchers may not provide the reader with a step-by-step description of the entire process, we must give enough evidence to establish that the procedures were carried out faithfully. Merriam (2009) argues that we must provide enough detail to show that our conclusions are derived from the data. Thus, the more detail I provide and the more I tell a well-told tale, the more reliable my work will be (Creswell, 2007). To ensure this level of detail, I created an audit trail so others could follow my research and my decisions from start to finish. Furthermore, I triangulated the study by using multiple sources of data and multiple theories to confirm my findings (Lincoln & Guba, 1985).

Seidman (2012) argues that the three interview structure enhances validity. It emphasizes context and allows the researcher to check for internal consistency across multiple interviews. Furthermore, when done with multiple participants, it allows the researcher to connect their experiences and to check one participant against another. Essentially, the three interview series allowed for increased validity because it created the opportunity for greater authenticity.

In addition to triangulating my data, I also shared my codebook with two other researchers to ensure that my codes were clear. These researchers coded two of my interviews using my codebook, and I looked to see how closely aligned we were in our coding. When we found discrepancies, we worked together to generate codes that were

more stable. I also shared my data and my analysis with my participants. I asked participants to verify transcripts, and I checked my interpretations with them.

Limitations

This study has various limitations that impacted both the data collection and the analysis. My selection of participants was limited to the teachers who responded to the survey. I was also limited by relying on teachers' self-reporting on the survey and during the interviews. Additionally, my own positive experience with the project may have limited my ability to hear and understand others' criticisms, and I may have had the tendency to compare others' experiences to my own. Both of these required that I carefully monitor my own biases. Having moved into the role of full-time graduate student, the teachers may no longer have seen me as an insider, and they may have filtered their responses accordingly. Seidman's three interview series is designed to break down these boundaries, but it may not have happened with all of the participants, particularly the one teacher who was critical of the project. Despite these limitations, this study has the potential to give us deep insights into the teachers' experiences. By keeping the participants involved throughout the process, I sought to overcome these limitations and generate an analysis that remained true to them and their stories.

Chapter 4: The SciJourn Project

In this chapter, I took a closer look at the SciJourn project examining, how SciJourn's definition of science literacy came to be, how the project's PD was designed and how the project evolved throughout its five years. Specifically, I sought to answer the following question:

- How did the SciJourn project build professional community and influence transformative learning?

Science Literacy and Writing in Science Classrooms

Science literacy. As I sought to explore how participation in SciJourn influenced teachers, it was important to situate this project within the literature on science literacy and the use of writing in science classrooms. The notion of science literacy is a contested one, which has important implications for the SciJourn project. Science literacy and its application to science education dates back to the 1950's when Paul DeHart Hurd formally introduced the term as a major theme for science education shortly after the launch of Sputnik (for a more detailed account of the history of science literacy see Bybee, 1997; DeBoer, 2000). Despite decades of research and discussions around science literacy, educators have yet to come to a consensus on an agreed upon definition. Nevertheless, science literacy remains one of the primary goals of science education.

Bybee (1997) argues that science literacy serves as a metaphor for the goals and the purposes of science education; thus, viewed metaphorically, science literacy means immersing students in the authentic practices of science as opposed to the meaningless operation of memorizing scientific terms. Bybee views science literacy as a continuum where individuals evolve to develop more sophisticated understandings of science and

technology. DeBoer (2000) suggests that science literacy is really about the level of scientific understanding that exists in the adult population. One's science literacy grows and changes over time. He argues that it is not about what students know while in school, as few students can be considered scientifically literate upon graduation. At best, they may have been introduced to science and the issues that are relevant to society; they may like science and feel invested enough in it to want to stay informed as adult citizens. Ultimately, science literacy implies that adults find science interesting and important while being able to participate in conversations regarding science and society. Roberts (2007) suggests that there are two visions of science literacy. Vision I considers the products and processes of science, requiring science knowledge. Vision II, on the other hand, considers the ways individuals encounter science as citizens, where science literacy is centered within science related issues. According to Roberts (2007) these two visions are symbiotic with one another. Roth and Barton (2004) suggest that science literacy be reframed as a collective practice rather than an individual pursuit, requiring that students have opportunities to engage in authentic scientific activities within their communities. They argue that science literacy cannot be pre-packaged in books or delivered to students in a classroom. Instead, it must be understood as community practice which is undergirded by a collective, social responsibility. Similarly, Lemke (1990) views science teaching as a social process, where the goal is to bring students into the community of people who talk science.

In today's information age, this authentic participation becomes increasingly important as individuals encounter scientific information in numerous forms throughout their everyday lives. In the most recent draft of the Next Generation Science Standards

(NGSS), science literacy is a common thread seen throughout the K-12 standards. The NGSS are based on the National Research Council's *A Framework for Science Education: Practices, Cross-cutting Concepts, and Core Ideas,* which identifies the key scientific ideas and practices that students should learn throughout their K-12 education. The framework is primarily concerned with "what all students should know in preparation for their individual lives and for their roles as citizens in this technology-rich and scientifically complex world" (National Research Council, 2012, p. 10). Among other key practices, the framework emphasizes constructing explanations for science, engaging in argument from evidence, and obtaining, evaluating and communicating information as practices that are essential to science and engineering education.

In 1929, John Dewey suggested that it is impossible to prepare children for the future because it is impossible to predict what civilization will look like in the next twenty years (Flinders & Thornton, 2009). Dewey's words are perhaps more relevant today than ever before. As we are in the midst of the age of technology, we are watching our world change at a rapid, sometimes even alarming, rate. None of us can predict our future world with any degree of certainty. As a result, it is impossible for us to prepare our children for their future jobs because we are not knowledgeable of the technological innovations of our future world. In this context, Krajcik and Sutherland (2010) suggest that scientific literacy for a global society in the 21st century requires an understanding of science concepts and principles, as well as being able to engage in the literacy practices that make the communication of ideas possible. They argue that while most students will not pursue scientific careers, they will encounter science throughout their everyday lives.

Thus, for today's students to effectively participate as citizens in tomorrow's decision making, they must be supported in learning to read, write, and talk science.

The developers of the SciJourn project embraced this notion of an unknown future world and defined science literacy as the skills students will need to successfully deal with the science-related issues they may encounter fifteen years beyond high school graduation (Saul, et al., 2012). The project was particularly concerned with teaching students to think critically about the scientific information they will encounter throughout their lives and was situated within an understanding that there are various ways to teach students how to read, write, and talk science. SciJourn's definition aligns closely with Roberts' (2007) vision II of science literacy, where individuals must be able to successfully navigate science-related situations.

Writing in science classrooms. The Common Core State standards place strong emphasis on discipline-specific writing, making writing in science courses an increasingly important endeavor. It is well known that students do not simply appropriate scientific knowledge and apply it to their lives (Jarman & McClune, 2007). Rather, scientific knowledge has to be reworked, restructured, and integrated with students' prior knowledge. Promoting meaningful learning in science classrooms demands the inclusion of writing tasks that facilitate this conceptual reorganization and restructuring. Rivard (1994) argues that tasks which maximize learning possibilities and develop higher order thinking skills will require students to expand understandings, reprocess concepts and ideas, hypothesize, interpret, synthesize, debate and persuade. Thus, writing in science is a resource for thinking and learning, an avenue for students to clarify and consolidate their knowledge.

Krajcik and Sutherland (2010) suggest that constructing explanations and arguments is an essential component of science literacy. Thus, it is critical for students to have opportunities to write about science and to practice supporting their ideas with evidence. The discourse of science includes not only precise language but also specific ways in which language is used and particular ways in which explanations and arguments are constructed. Writing in science typically emphasizes the traditional lab report. This approach assumes that the best way for students to learn to write scientifically is to mimic the work of professional scientists. Some researchers argue that science classrooms need to include diverse forms of writing, requiring that students write for different purposes using various audiences (Prain, 2006; Prain & Hand, 1996). In their study of writing to learn strategies in secondary Biology classrooms, Hohenshell and Hand (2006) found that engaging in different writing tasks, such as pre-writing and summarizing, provided students with a different set of cognitive experiences compared with the conventional laboratory tasks associated with science writing. Writing summaries, for instance, helped students to integrate their understandings. Similarly, Hildebrand (1998) reported that diverse forms of writing were motivating for students and had positive effects on learning processes and outcomes. Rivard and Straw (2000) investigated the role of talk and writing on learning science. Their findings suggest that talk was used by students for interpreting tasks, and for generating, sharing, and focusing ideas. Writing, on the other hand, was used to organize ideas into coherent responses, was more focused, and placed greater cognitive demands on the students. They argue that talk is a necessary precursor to writing, but writing is critically important for the retention of science knowledge over time.

SciJourn. Despite the popularity of news and media, there are few studies that consider the use of news resources in the science classroom. Jarman and McClune (2007) offer one exception as they consider how reading news media can be used to cultivate science literacy in the classroom. They argue that science in the news demonstrates relevance of science in everyday life and bridges the classroom with the wider scientific world. Stories in the news are also current, dealing with contemporary issues in the community. Newspapers also offer a local perspective that may make the content more relevant and engaging for the reader. Essentially, they suggest that teachers can capitalize on the news to help students connect to the science that surrounds them.

SciJourn aligned with this perspective but was unique in its cultivation of science literacy through the use of an apprenticeship model, where students were not only asked to read science news, but were invited into the conversation as science journalists. The SciJourn project was designed to answer the following question: Does the teaching of science journalism using an apprenticeship model, reliable data sources and science-specific writing standards improve high school students' understanding of and science-related public literacy? Sub-questions included: 1) Is the teaching of science journalism an efficacious replicable and sustainable model for improving science literacy? 2) How useful are science-related standards and rubrics for scaffolding and evaluating students' science writing? 3) What is the nature of the engagement in science this apprenticeship model invites? (Polman, et al., 2008).

As science journalists, students called on multiple, credible sources of information to research topics of personal interest and then they synthesized this information into news stories targeted to a general audience (Polman, et al., 2012). A foundational premise

of SciJourn was that students need to learn to evaluate the credibility of sources of information, a life skill that will enhance their science literacy well into their adult lives. As such, the project attuned teachers and students to the process of researching and writing for science news. By asking students to step into this genre, SciJourn gave them the opportunity to start thinking, feeling, and reacting like a journalist. The intention was that science would no longer seem out of their reach. In his work, Charles Bazerman (1988) found that even professional scientists find themselves reading texts that they do not understand. The difference between these scientists and most students is that the scientists use reference materials to figure it out whereas the students stop reading. If we can teach students that this is part of the journey to scientific literacy, then perhaps they will be encouraged to stay the course and keep going even when they do not understand. Science journalism gives them a unique avenue to explore science in an investigative way that is both fun and engaging. Most importantly, science becomes accessible to them. Thus, participation in SciJourn was simply another way to invite students into the conversation of science. By inviting them into the conversation, students were given the opportunity to become part of the scientific community while also cultivating the science literacy skills that are necessary for success in an unknown, future world.

A New Conceptualization of Science Literacy

The making of a new definition. SciJourn defined science literacy as the skills students will need to successfully deal with the science-related issues they may encounter 15 years beyond high school graduation. Before I explore the influence of this definition, it is important to put this definition into context and explain how it came to be. Of interest is that the definition was not established until the third year of the project. After

the project's second year, members of the research team visited the National Science Foundation's (NSF) headquarters to report on their research. During that visit, the team presented the project's guidelines (see Appendix I), which had been written as a set of standards to help lead the project. According to Saul and Newman, the guidelines did not resonate with the representatives from the NSF, who were critical that the project was not being explicitly aligned with content standards. As a result, the team members came away from the meeting tasked with the need to re-contextualize their guidelines. Saul explained:

> What we needed to be able to do is show what our guidelines answered, what was the question that our guidelines could answer. And we had a lot of trouble with that. And Alan thought about it and this came directly from him. It was not from anybody else. He said, "You don't want to just know what is happening in chemistry, or biology, or physics. You really want to know what we can teach them that will have meaning fifteen years out."

As Newman intentionally thought about the conceptual underpinnings of the project's guidelines, his thinking was entrenched in his sense of journalism. He explained that he realized that anything you can teach in the moment eventually becomes dated. Although there are fundamental scientific concepts, those concepts typically are not central to the kinds of questions that people ask. According to Newman:

> The questions that people will ask in the future are things that you really, often, can't teach. What's the best computer for me? What's the best car for me? What's the best treatment for my type II diabetes. And these are always evolving questions, and so understanding force and motion doesn't help you buy a car even

> though those are fundamental properties of cars. And so the question is, obviously, what skills can you give students that will help them answer those types of questions fifteen years out.

Once this definition was established, the guidelines became increasingly purposeful as they offered a designated skill set that could foster this form of science literacy.

Although SciJourn's definition of science literacy stemmed from journalism, it resonated far beyond the scope of science news. The definition also had important implications for teaching and thinking about what students should know and be able to do, which had a profound influence on the project. Saul explained:

> Once we had that definition, we could answer the question of what to teach, which we weren't thinking about beforehand. We were only thinking about processes and writing and that question broadened. It was like getting a new tool in the toolbox.

With that definitional tool, the project became increasingly influential because the definition made sense for the teachers involved and helped them to understand SciJourn's purpose. As Newman explained, "The nice thing about fifteen years out -- it's our elevator speech. It just resonates. It gave us a simple platform on which to talk about everything else."

Because the definition was not fully developed until the third year of the project, it is important to note that the first two groups of teacher participants were not given the definition during their summer training. Prior to the definition, however, the project did have the guidelines, which emphasized searching for multiple, credible sources of information. The teachers from these first two groups were eventually introduced to the

definition during the ongoing PD sessions starting in the project's third year, and the SciJourn team continued to work with that definition for the duration of the project.

When it comes to science literacy, Newman (and researchers like Roberts, Lederman and Yager) perceive that there are two different camps of science literacy. One is focused on science content, which he views as the traditional approach to science literacy. The second is focused on public engagement with science and public understanding of science. This perception of science literacy emphasizes the skills that individuals need in order to answer their scientific questions. According to Saul, however, it is not just about answering questions but also knowing how to ask appropriate scientific questions.

On the other hand, there are certain fundamental concepts that people need to understand such as DNA or knowing what a cell is. While adults should understand the concept of a cell, they do not, necessarily, need to know the parts of the cell because they can easily look them up. This, according to Newman, is where the two science literacy camps diverge. He explained that if a student wants to be a biology major then he or she should know the parts of the cell. Yet, the majority of students will not pursue science as a profession, so the content currently taught is really tailored to a very small percentage of the population. In turn, the result is that many students dislike science because of the emphasis on advanced concepts that are rarely used in real life.

While certain scientific concepts are fundamental to science literacy, equipping students with the skills they will need to be able to navigate scientific information 15 years beyond graduation is also fundamental. According to Saul, the definition "helps us differentiate what's fundamental and what isn't. This helps us. If it's going to be true

fifteen years out, then you need to teach it." When it comes to teaching students how to ask questions and how to find credible sources of information, journalism is a perfect fit. Newman explained, "We follow a model of what science reporters do because they are always asking questions in the moment and re-discovering new stuff."

Transformative Professional Development

Designing SciJourn. Implementing various forms of writing in science classrooms necessarily involves teachers finding value in these writing processes. Additionally, they need to feel comfortable in both teaching and supporting their students as developing writers. In their investigation of two science teachers' changing perceptions and concerns regarding implementing writing-to-learn strategies in their classrooms, Hand and Prain (2002) found that science teachers must negotiate a range of complex issues when implementing diverse writing techniques. These include developing their own knowledge about the nature of writing, determining which kinds of writing to use, and designing appropriate classroom activities to support student learning. They argue that the research literature has not provided detailed, context-specific research on the ways teachers have grappled with and changed their beliefs and practices in response to these issues. Their research showed that the teachers had to adopt new pedagogical strategies and needed an extensive time frame to devise, trial, and evaluate the various writing tasks as they were being implemented. The teachers ultimately gained an understanding of writing-to-learn through a process of apprenticeship, guided participation, and participatory appropriation. Training teachers in the genre of science journalism was an important and necessary part of the SciJourn project. Most science teachers are unfamiliar with the genre of journalism and journalistic conventions. Thus,

PD, support, and flexibility were important pieces of the equation as science teachers were asked to step into a new, and sometimes uncomfortable, role.

To this end, SciJourn was developed as a partnership between university-based researchers, a professional editor, and classroom teachers. According to Saul, who was the primary designer of the PD sessions:

> There are certain key ideas that guide every PD that I'm involved in. One, is that teachers are smart and they need to be treated as smart and co-creating whatever it is what we do. A second idea is that you have to move from whole to part to whole. And a third idea, is that it needs to be authentic, it needs to be something that exists in the real world, not just in schools.

From her point of view, there also needs to be three parts to every PD. Concepts and strategies must be modeled, teachers need the opportunity to unpack those concepts and strategies, and teachers then need to apply them. Based on these tenets, Saul explained that much of what she did in SciJourn's PD she borrowed from the National Writing Project. In modeling the PD after the NWP, it was critical that teachers volunteer to participate. Though some of the researchers and teacher participants recruited teachers to the project, ultimately, teachers came to SciJourn by choice, indicating that something about the project aligned with their needs and captured their interest.

PD during the first year (the pilot year) took on design research model. Thus, the teachers and the research team were essentially co-creating the experience together. During that year, one teacher came up with the idea of doing infographics instead of writing news articles. Another teacher did not want to have his students write, but instead, wanted to focus on reading. Based on that, they began incorporating read-

aloud/think-alouds. According to Newman, the PD focused heavily on journalism that first year, and they spent a lot of time explaining the structure of a news article. Later, they realized that was a mistake because teachers took that same emphasis on journalism back to their classrooms. The students, however, did not want to hear about how to write the article, but instead, wanted to just jump in and start researching their topics. Newman explained:

> I realized even if they wrote a five paragraph essay, it was much more important to get them to understand multiple credible sources and up-to-date and all that other stuff than it was to have them write a journalistic article. I can actually restructure it.

Saul also noted that during the first year, they were much more product-oriented rather than process-oriented. They also tended to be sequential, starting from the beginning of the article and moving to the end of the article. After that first year, they learned that it was more important that people authentically view themselves as being able to deal with multiple credible sources, to understand attribution, and to know what a good topic is. In other words, it was more critical that the teachers understand the guidelines rather than the structure of the news article itself.

After the first year of implementation, they also had students who had written and published articles, which gave them some sense of what students were capable of doing and some of the issues that would arise. During that first year, they learned that it is very difficult to divorce students from the model of the five paragraph essay, which has been their primary model for writing. They also encountered issues that were unexpected such as having to deal with plagiarism and the difficulties that students had in searching the

internet. Based on those lessons, the PD for Cadre 1 and Cadre 2 were much more focused, with significantly less emphasis on the structure of science news and more emphasis on the guidelines. They restructured those sessions to focus on the guidelines and approached implementation from the perspective that students need to just "jump in". They also had a better sense of what worked in the classroom and how teachers' successfully structured their lessons. While teachers were still given the freedom to modify the project to their specific needs, the PD gave them a structure to start with.

Newman referred to teachers classroom experiences as "war stories" and explained how important the ongoing PD sessions were because it allowed teachers to come back together and report on what they were accomplishing and the struggles they were having. He explained, "So we started collecting these war stories and revising things." Those revisions included lessons on how to do internet searching, how to choose good topics, and the importance of contextualization. According to Saul, their "big learning" came from seeing teachers struggle with having students complete revisions and also with grading the articles. Those were two of the primary concerns of the teachers, which the research team had not anticipated. In the beginning, the teachers also felt that the editor's comments were too harsh and were concerned how their students would take his feedback. As a result, several of the teachers did lessons on how to take professional criticism. The editor's comments were very different from the typical revisions that teachers would suggest. Saul explained that his feedback was "actionable" whereas the teacher's comments tended to be vague and focused on spelling and grammar.

Saul also noted how important it was to honor the teachers' authority. She explained, "What we've learned over and over again with SciJourn is how much you learn from being in the class with teachers." Thus, the researchers spent significant time in teachers' classrooms offering support and also doing classroom observations. As the editor, Newman was typically invited into classrooms early on to assist with topic selection and to help with pitching topics. From his perspective, teachers struggled because they wanted all of their students to be in the same place at the same time. He encouraged teachers, however, to let students begin researching as soon as they found their topics. He was also invited into classrooms once students got to the editing stage so he could discuss his edits with them and clarify his feedback.

When asked to look back and think about what they would do differently, both Newman and Saul agreed that starting the project in secondary school is too late, saying that it was almost "too much to try to teach high school students all we had to teach in one unit." From their perspective, the fundamentals that the project teaches belong in elementary and middle school. Ideally, they could start in a lower grade level and build on the skills each year. According to Saul, they did not emphasize revision enough and as a result, the teachers did not leave enough time for revisions, which is where much of the learning occurs. Additionally, Newman explained that it would have been interesting to explore if there was a simpler way of meeting their standards, rather than writing a news article. He acknowledged, however, that the authenticity of the journalism model was a primary motivator for many students. Nonetheless, he would have liked to have pursued having students do a slide presentation in front of the class. Saul supported this idea but was clear that revision was essential. According to her:

> It's still communication, but I would never do that without providing time for revision. I think revision is so important. And if the slide presentation allows for revision rather than writing, and you know I like writing, I would go for the slide presentation and then maybe give the slide presentations to the English teacher and have him or her work on the writing.

From her perspective, what was essential to the project, however, is that they kept building on what they learned.

For Newman, the project highlighted some of the problems with the current educational system. He explained:

> There are so many facets of this project that haven't' been explore and shows problems in teaching, and I don't know how to sort of wave the flag and say this is a huge shortcoming. To give you one that I keep talking about, is kids cannot read a sentence like, "In 2010, we estimated 50,000 Americans will be diagnosed with Type II Diabetes." They don't understand what that sentence means and it is such a common language in terms of health. It seems like a real shortcoming.

Consequently, both he and Saul are keen on the notion of health literacy as an offshoot to science literacy. They explained how their experience with SciJourn exposed some important issues around health literacy, particularly in underserved communities where students are dealing with some heavy medical issues. According to Newman, the current approach to health education assumes that teens do not deal with adult issues, which is flawed because families are very involved in dealing with health problems and there is no recognition of that in the curriculum. Similarly, Saul explained that the reasons to learn

science are viewed differently than the reasons to learn about health. Science learning is about being career and college ready, whereas health is about being life ready.

Chapter 5: Stories to Live By, Transformed

The purpose of this chapter is to uncover the influences of the SciJourn project on teacher participants. Specifically, I sought to answer the questions: How did participation in the SciJourn project influence science teachers' professional identities, knowledge, and classroom practices? In what ways were teachers transformed?

The five teachers whose stories are presented here teach in five different districts and have varying levels of experience (see Table 2). All of them are science teachers. Three of the teachers, Brian, Johnny, and Charlotte, teach in average or low performing schools. Two of the teachers, Denise and Jessica, teach in high performing schools. Additionally, Charlotte and Jessica teach middle school students, while the other three are high school teachers.

Of importance is that each of these teachers came to the SciJourn project through their own initiative. The project was not targeted for specific districts or schools. Therefore, these teachers found the project and chose to participate on their own accord. Based on that, each of these teachers conveys a sense of responsibility and agency for his or her own professional growth. It is my impression that these are not the type of teachers who sit back and grow stagnant in their teaching practices, but instead, they continuously seek to improve and refine their teaching craft. Additionally, each of the teachers here transitioned into teaching after pursuing other fields of interest. For some of them, this transition happened while still in college, and for others, the transition occurred after they had begun other careers. However, none of these teachers graduated from high school and went directly into the field of education. Consequently, they each

have a science degree and an education degree, meaning that they have expertise in their content and are designated as highly qualified teachers.

Table 2

Teacher Participants

Participant	**SciJourn Cadre & Year**	**Subject/Grade**	**Years Teaching**	**School**
Brian	Cadre 2 - year 3	High school chemistry (11)	6	Urban
Johnny	Cadre 1 - year 2	High school chemistry (11)	9	Suburban
Charlotte	Cadre 2 - year 3	Middle school science (7)	14	Urban
Denise	Cadre 1 - year 2	High school chemistry/Authentic science research (10-12)	16	Suburban
Jessica	N/A - Introduced to the project through the book *Front Page Science*	Middle school science (8)	3	Suburban

Chapter overview

In this chapter, I use data from the first interviews to introduce each of the participating teachers and explain why they were selected for this study. I offer an overview of each teacher's interest in science and his or her teaching context. I then present each teacher's storied account of his or her experiences with the SciJourn project, followed by my interpretations. Each case is presented separately, followed by individual analysis. The cases are presented in the order of their level of influence based on the survey results: the first two cases were both highly influenced, the third case was moderately influenced, and the fourth case was only slightly influenced. The fifth, and final, case that I present is unique; she is teacher who found and implemented SciJourn on her own, without attending the summer training. While the interpretations are representative of my insights, the stories presented here come directly from the interview transcripts, thus, preserving the teachers' voices and words.

Cases

Charlotte – "Science has become, to me, to be just beautiful." Charlotte and I became acquainted during SciJourn's PD, sitting next each other throughout the two-week workshop. While the majority of the SciJourn participants were local, Charlotte travelled from another state to participate in the project.

Based on her survey responses, I categorized Charlotte as significantly influenced. Her responses clearly conveyed her appreciation for the project. She replied to question 10, which asked what influence the project had on her understandings of science literacy by writing, "I thought I knew about credibility but found out that I did not. I have a much better understanding of research, citation, reading and writing skills needed for the 21st Century and that high expectations for middle school students result in higher

achievement!" Additionally, in response to question 12, which asked what aspects of the project she would still be using five years from now, she replied, "All of them! I cannot imagine removing such a motivating, exciting, challenging and educational tool from my teaching!"

Charlotte was always very vocal about her positive perceptions of the project. I selected her for this study because I wanted to know more about those perceptions. I was also interested in her story because she was one of only a few middle school teachers involved, and her implementation of the project seemed to be successful as evidenced by the number of students she had who published articles.

Charlotte is a middle-aged, white female who teaches in her district's magnet program at a math, science, and technology-focused middle school with 1,100 students. Her school is an urban school, serving a diverse student population where 59% of the students are white, 34% are African American, and the other 7% are either of Asian or Hispanic decent. Sixty-five percent of the students receive free and reduced lunch, and 50% perform below proficiency cut-offs on state assessments.

Over a couple of days in July 2013, Charlotte welcomed me into her quiet, country home, where we sat at the kitchen table for her interviews. There, she described to me, in her quiet, southern drawl, how she went back to school to become a science teacher when she was in her forties. Charlotte, who calls herself a baby boomer, recalled wanting to pursue teaching when she graduated high school but was discouraged to do so because jobs were not plentiful at the time. When she returned to school later in life, she had heard that language arts teachers struggled to get jobs, so she opted to pursue science instead.

When she first went to college, Charlotte wanted to join the Peace Corps so she studied sociology, but then she was forced to drop out because her father stopped paying her tuition. Her father, according to Charlotte, told her "you can change the world by being a secretary." So she quit school and went to look for a job. The only job she could find was working at a gas station, which she referred to as a "man's job." She then got married at 20 years-old and supported her husband through multiple degrees while working at McDonald's. She was eventually promoted to a salaried position and worked there until her children were in middle and high school, which is when she decided to get her teaching degree.

According to Charlotte, she was "scared to death" when she started classes but "just kind of took the bull by the horns and did it". She completed a five-year program where she got a bachelors degree in biology along with her teaching certificate, and then during the last year, she received her master's in teaching. She was pre-hired by her district because she was a science teacher but did not expect to teach middle school. When they told her she would be teaching middle school, she told them she was not qualified. She had only ever envisioned herself teaching high school and never considered that middle school might be an option, but she ended up being placed in a seventh grade classroom and has stayed there for 14 years.

According to Charlotte, "I think science, has become, to me, to be just beautiful. I can teach so many things through science." She said that her ultimate goal, as a teacher, is to make her students love science and understand that it can explain their world. She described how sometimes her students come in hating science and she sees it as her job to turn that around.

As she reflected on her own experiences in school, Charlotte suggested that she was not a very good student, and she found science to be "dry and boring". When she went to high school, however, Charlotte knew that she wanted to get into a good college so she refocused and her grades improved. Nonetheless, her science classes were not interesting to her and she often felt “petrified” of science. She credits that as part of the reason she became a science teacher. She wanted to teach science so it would be accessible to her students and they would not be afraid of it:

> I think differently of science than a lot of teachers. I don’t think of it as just being lab work. I don’t think that – and that there’s such a thing, it’s also that you have to make them think like a scientist. That’s a part of it, but I think the bigger part is the wonderment of science.

Though she has stayed in the same district, Charlotte has taught in multiple schools ranging from very low performing schools to magnet schools for gifted students. Her current school, she explained is a “good balance” with both advanced students and students from the neighborhood whom she refers to as "resides." She also spoke of her principal, whom she described as being very supportive. According to Charlotte, she intends to say in her current school unless she is given the opportunity to teach at the high school level.

Charlotte described her district's approach to PD as "sit-and-get" where teachers are expected to learn strategies with no follow-up or support. She also explained that her district introduces one new thing after another, with little follow through on implementation. According to Charlotte, "After you've experienced that over and over again, you kind of shut down...those are just frustrating, so a lot of PD that I've gone to

has just been frustrating." However, an exception was Charlotte's experience with the National Writing Project, which she described as "amazing" and critical to her teaching.

Her experience with the National Writing Project influenced Charlotte to incorporate more writing in her science classes so she had her students write children's books on extinct animals. She required that the books have a story line and not just be a list of facts. She discovered an online program called Realewriter where her students could publish their work. According to Charlotte, once the opportunity to publish was available, "the excitement level was so high, they wanted to do the project."

Her students were also required to do writing portfolios as part of their state assessments so she was forced to focus heavily on literacy. Charlotte explained:

> When they first told me when I went into this middle school that I was a reading and a writing teacher, I was absolutely shocked. I had not had any training for that in a high school program. And I said, 'No, I'm not' when they first said it, I thought when they were saying reading that I was going to try to teach them sight words, you know and so I was like, 'Well, how do you do this? I don't know how to do this. I have no clue' and they said, 'figure it out'. You know, there was no help involved.

Because of the lack of support, Charlotte was forced to seek out PD to help her learn how to incorporate more literacy and writing into her classes, which is how she found the National Writing Project. The result is that she now focuses more heavily on writing than most science teachers, calling herself the "odd man out." She said that she does not want her students to fear science, and she also does not want them to fear writing because she views it as an essential skill.

Though her school is a technology school, Charlotte explained that it is nearly impossible to get into a computer lab. So, in order to support her students' writing, she got acquainted with her school's technology representative and any time she found an extra computer, Charlotte asked her to place it in her classroom. Charlotte spent her own money and purchased switches that would allow her to hook the computers up to the internet, and she "just kept getting old computers." She said that using the switches is not legal in her district, but she decided to go ahead and if necessary, "ask for forgiveness later." Over time, she accumulated 28 computers for her classroom, and though four or five of them are down at a time, her students still have access to technology for research, which has helped her prioritize researching and writing in her classes.

Charlotte's SciJourn story. Charlotte began her second interview by explaining that she became involved with SciJourn through her extensive work with her local chapter of the National Writing Project (NWP). Her chapter of the NWP does not have many teacher participants who are science teachers, so she helps them in designing and implementing content specific PD and training. When members of her team heard about the SciJourn project, they asked Charlotte to attend the training and to report back to them about the program.

Defining science literacy. For Charlotte, SciJourn's definition of science literacy was significant. She explained that prior to SciJourn, she did not understand science literacy "at all." She had always thought of science literacy as being able to write a lab report and knowing science vocabulary. When it came to reading scientific text, her school had so few resources that she felt it was "kind of irrelevant." When SciJourn

presented science literacy within the context of being able to read science on the Internet, it challenged Charlotte's thinking:

> I had no idea about credibility of sources. I thought I did. I was a college graduate. I should know about credibility of sources, but when we went to school, everything was already vetted. It was you go to the library and you got books or magazines. You knew those were credible, so you didn't think about it much. Whereas now, when you get on the Internet, there's everything out there.
>
> So how do you teach that? I don't think anybody has taught us how to teach that.

This realization influenced Charlotte to start thinking about the skills that her students will need 15 to 20 years from now. She described how her teaching priorities began to shift as she moved from focusing on lab skills to teaching her students how to find and discern scientific information. According to Charlotte, she's particularly mindful of the credibility of health and medical claims:

> It's kind of scary now where before you always just went to your doctor and that's where you got it. You didn't get it from anywhere else. Your mom might tell ya, but you kind of knew she wasn't always credible, but now, the world is just open and even my daughter will pull health things up and swear that this is the next best thing.

Beyond teaching credibility of sources, Charlotte also valued the writing process, which she believes helped her students to think more critically. As a result, her focus has moved from teaching content to thinking about ways to embed a higher level of thinking into her assignments: "I think that's - it's not so important that they memorize the layers of the earth or the layers of the atmosphere or the rock cycle. It's more important, I

believe, that they're critical thinkers." Charlotte went on to explain that she thinks SciJourn should be a requirement as part of the standard curriculum from elementary through high school. She views the project and its ideas as being "that important" because they teach students to "function in the world." According to Charlotte, "I don't know that there's any other vehicle that I know of that really does that, but this kind of project." She also noted that when she went through the Common Core State Standards, SciJourn touched on all of the reading and writing skills except for one, which was writing a concluding paragraph, a technique that is not used in the journalistic model of writing. She explained, "It's one big project yes, but it covers all of the Common Core requirements for reading and writing. It's that powerful."

Engagement and authenticity. Charlotte was also highly influenced by her students' engagement with the project. She explained, "I think the engagement part is as important as the science literacy part." When she first showed her students the website, SciJourner.org, she explained to her students that all of the authors were in high school and then challenged her students to be the first middle school students published. She had many students who were up for the challenge and "they would be working like little bunnies." Charlotte was also surprised by the students who succeeded with the project. Many of the students who were enthusiastic in the beginning were not the ones who got published. She said that she could not necessarily predict which students would follow through and have the stamina to complete the edits. When a student was published, she made a point to celebrate it. She displayed their pictures in the hall, and they were applauded in the school announcements. According to Charlotte, during that first year:

> I learned that they could do it. They did it under pressure, as middle schoolers, and they felt really proud and the majority of them really, when they wrote the reflection, they really were proud of what they did, even if they didn't get published; that the experience was a good one. She also noted that her students felt special because they were not only the first middle school students working on the project but also the only students in their district who were participating.

Charlotte was impressed by what her students learned from the project as she heard them talking about multiple, credible websites and discussing how to cite sources and how to avoid plagiarism. She was also impressed by their tenacity. She described how almost all of her students contacted an expert in the field of their topic and many actually got responses back, which made "the world of science so much more real to them." She felt that it empowered her students to be active in their learning and to want to learn more about their topic: "when the first person gets that reply back from the scientist, they just get fascinated with that. It's fun to watch them light up and to see what's possible."

That authenticity was also significant. Charlotte explained how excited her students were at the prospect of writing a news article that could get published and also be on the Internet forever. For her students, being able to call themselves a published author was a "big deal" and likely an experience they'll never forget. Beyond the researching and writing, her students also learned how to report on data. According to Charlotte, her students did "tons of surveys," and most tried to get over a 100 responses. They also learned how to report out that data, which she feels is a critical scientific skill. She also described how the revision and editing process was important:

> Going through the steps of doing an extended writing piece where they revisit their piece and edit it and relook at it and do peer editing and come up with that final, it gives them the stamina to stick with something. And I think that's something that's also missing with our students is that stamina to stick with something over time and to value that work that they're doing and to take personal ownership in it.

Charlotte's students' engagement was closely tied to their being able to choose their own topics, a process that she describes as "striking." Many of her students chose to write stories on health topics, which were important to them or their loved ones. As they learned more about their topics and shared stories in class, she felt that it bonded their classroom community. She also explained how the process empowered her students. She told the story of a student who was often frustrated because he felt that he should have been placed in an advanced science class. When he was given the SciJourn project, however, he felt like he was working on something significant. She explained how she saw him "blossoming" and she could see that he was doing something that made him feel proud and gave him a sense of achievement. According to Charlotte, the project had a very positive impact on many of her students and many of them spoke about the project with "almost a reverence":

> I really do want to share the essence of it because really I do want to share that because it's something that goes on in my room that you can't share. You know, you can't - it's almost a real thing that you can feel when you walk into the room. And I think that's something that I wish we could capture. You know, I wish everybody could feel that because it's a stronger force than just writing. It's a

> stronger force than just science. It's bigger than that. It just became a bigger - its own entity that I think every student should experience.

Professional development. SciJourn's PD sessions were also influential to Charlotte's experience. She explained how she was impressed by the leadership of the project from the very beginning, which made her feel invested in it, "you could tell they were putting so much of themselves into this and they really believed in what they were doing." She also described how the summer workshop thoroughly covered every skill that she needed to implement the project and she appreciated that the meetings were not "sit and get" but rather, teacher centered.

When she learned that she would have to write her own article, Charlotte was nervous but ultimately, found the process very useful. Because she was sensitive about her writing, she struggled to go that last step did not finish her final revision. However, she shares her marked up article with her students to show them that she went through the process. According to Charlotte, "That's good PD where you experience what your students are going through so that you understand why they are so, maybe can be reluctant or nervous or what pitfalls they are going to run into."

Charlotte also valued the sense of community that she felt with the project and felt inspired during the follow-up sessions:

> I loved coming back into that positive atmosphere. You just don't see that everywhere, where you feel like you're coming home. You feel like you're with like-minded people. That everybody's there to learn and to get better and to share what worked and what didn't. And I really miss that positive atmosphere of that training.

Through that positive atmosphere, Charlotte developed relationships with other teachers, who motivated her as she worked through implementing the project in her classroom. For Charlotte, the PD was critical to her experience:

> All the things they teach you, you practice looking at and those are the exact same things that I do with my students. So, I think experiencing it for the two weeks was really important. It gave you time to synthesize it, to feel it, kind of get your head around it and to know that this is something that you want to do with your students.

She also valued the support that she received from the SciJourn team, particularly the editor, who would take her students' writing to the "next level" and really make it publishable. According to Charlotte, "I've learned a lot about what needs to go into it through reading his edits and seeing what he's done to fix it."

A new story to live by. Prior to SciJourn, Charlotte's story to live by had two prominent plotlines. The first was that she perceived herself as a science teacher who valued writing as a skill, a story that emerged from her participation in the National Writing Project. Within that story, however, Charlotte felt conflicted because she questioned her expertise as a reading and writing teacher. The second plotline was that she wanted to be a leader in her school district but was met with resistance. Charlotte's desire to be a leader was evidenced in the initiative that she took to lead PD and also when she changed schools so that she could be a department chair and a team leader. She is also in graduate school working on her doctorate. She explained, however, that in her district, she was the "oddball" science teacher because she placed so much emphasis on reading and writing and tended to "buck" her curriculum. Therefore, while she wanted to

be in a leadership role, she found that other science teachers pushed back against teaching literacy practices, while literacy teachers doubted her knowledge.

Despite her participation in LWP, Charlotte continued to doubt her abilities as a writing teacher:

> I honestly didn't think that I would be able to have students focused on one thing and have them be able to write this kind of piece over time. I was skeptical when I came in that as other science teachers are - and I'm sure other content teachers are - that we can't do that editing like a language arts teacher.

Because of that, she felt that she could get her students to write a piece, but then she had to turn it over to the language arts teacher to finish it, "like get those language artsy things in there." She was confident in her content skills, explaining that she could get the science correct but not necessarily the editing piece.

In the past, Charlotte used various writing activities in her classroom including brochures and feature articles, which she described as "useless." After her participation in SciJourn, however, Charlotte explained that she has gained confidence and that the journalism model is very specific and does not feel overwhelming when editing. As a result, her skill level has increased and she now feels that she can get her students to create a richer product. She described that experience as "powerful" and explained that now, when her students write, she works to make it meaningful so that her students are critically thinking about "what they're writing and about the subject they're writing about." As a result, her students' test scores have increased and her classroom is a richer learning environment :

> My test scores are higher than the other two science teachers in my building and they're good teachers, but I think what my kids can do is critically think on the test. They can attach even a multiple choice question and look at it and say, "What is it asking me?" Not just memorizing what it is, but understanding the question. I think it's given me a richer look at everything that they produce. It can't just be a throwaway, fill-in-the-blank question. It's got to get them thinking.

Charlotte described how teaching science content has become secondary to teaching literacy and writing, which she believes are the skills that students need in order to succeed. She explained this shift in her thinking by saying that she "kept putting her toes and then her feet in." At first, she was told she was a literacy teacher, and she had no choice. But she wanted to do it well so she sought out ways to improve. Through the National Writing Project, she explained that she "started to feel it, but still wasn't there." During the SciJourn project, however, she began to feel a "complete immersion into being a reading and writing teacher." As a result, when she hears or sees something about a literacy strategy, she tries to devise a way to embed it into her teaching, whereas before, she thought of it as "just another thing you're giving me." Through her SciJourn experience, Charlotte's story to live by evolved from being a science teacher who valued writing as a skill, to being a science teacher who has the expertise to successfully teach reading and writing.

At her school, Charlotte has had difficulties getting other teachers interested in the project. She described having a very negative reaction from other teachers, particularly language arts teachers, who do not believe that she has any literacy expertise. Charlotte explained her frustration with those "politics" because she strongly believes in the power

of the project and views it as "the thing that all content areas could embrace as a way of teaching students those essential skills that they need." Her participation in SciJourn, however, gave Charlotte multiple opportunities to take on leadership roles and to cultivate relationships with like-minded teachers. She shared SciJourn with other teachers involved in the National Writing Project and also the Kentucky Department of Education. She also presented at a National Science Teachers Association conference on using SciJourn in her classroom. When she returned from the SciJourn summer workshop, she reported to the National Writing Project on the experience and then was invited to work with them on developing a writing continuum across content areas. She was then invited to serve on a "writing task force" committee with her school district and wrote a module for the Literacy Design Collaborative. She credited all of these opportunities to SciJourn: "Because of SciJourner, I've gotten these opportunities and hopefully am sharing the SciJourn process." Thus, her story to live by evolved as SciJourn gave her an outlet to take on a leadership role and to share her expertise with other teachers.

Transformation. Charlotte's new story to live by points to transformative learning. Charlotte's disorienting dilemma resulted from her wanting to incorporate more writing in her classroom but not feeling adequately equipped with the skills to assess her students' writing. When she began her SciJourn training during the summer institute, her assumptions around science literacy were challenged as she began to think about the skills her students would need 15 to 20 years down the road. She had a moment of realization that sources of information have evolved and her students were not being taught to find and assess the credibility of information on the Internet. In response, she recognized that her teaching priorities would need to change.

During the summer workshop, Charlotte acquired the skills that she needed to take the project back to her classroom, and she developed a plan for implementation. Learning to lead read-aloud/think-alouds were an important part of her transformation as she explored her various options for implementation. In so doing, she felt the read-aloud/think-alouds were the most efficient and effective means of teaching students how to assess credibility:

> I didn't know to go to the About Us to look further into the sites and who was backing the site and who was buying advertising and were they selling anything and did they have credentials? Was it sponsored by a company that could be biased?

Prior to SciJourn, she had heard of read-louds/think-alouds but had always associated them with reading literature out loud to her students and felt it was "stupid" and would not work in her science classroom. When the read-aloud/think-alouds were modeled in the SciJourn training, they had a clear purpose and were related to science, proving to be a method she could use.

***Implementation*.** When Charlotte took the project back to her classroom the following school year, she introduced it to her students the first day of school. That year, she implemented the project with two of her advanced classes and one of her "comp classes" (a group of average students). In the beginning, her students were enthusiastic, but then it took awhile to get everything up and running because she had to get IRB forms signed and her students had to take the Science Literacy Assessment (SLA), a rather long test that was designed for high school students. Charlotte formally began the project in January of that year, at the start of the second semester. She started by doing

read-aloud/think-alouds of articles from SciJourner.org and also Science News for Kids. From there, she had her students choose topics, which took much longer than she expected. Her students worked in pairs, choosing their partners. According to Charlotte, "I just feel with seventh graders, they're so social that when you tell them they can pick their partner, they immediately become more comfortable with the project." As a result, she found that her students were inclined to work outside of school since they were with their friends. They also found it easy to choose topics that they were both interested in. However, in her first year she had several "divorces" where the pairs split up during the process because of various disagreements.

Charlotte also required that all of her students write a finished, revised article. She suggested that only requiring a rough draft would be a disservice to her students because they need to be taught the value of editing. According to Charlotte, "That's another skill they have to have, so even if they don't published, the skill of writing a finished piece." Implementing those revisions, however, took longer than she expected, and they were still sending off articles on the last day of school. Some of her students never finished because they ran out of time.

Charlotte explained that the first year was rough and her timing was off, so she revised her approach, and the next year, she began the project right away in August. That year, she pushed her students harder on refining their topics, challenging them more when they were attached to an idea that was not feasible. She learned from the first year that she needed to be more up front when the topics were not appropriate. She also had heard from her previous students that she had put too much pressure on them, so during the second year, she "backed off quite a bit". She gave them more time on the computers,

which proved to be ineffective. According to Charlotte, "They had me bamboozled. So, we got, again, towards the end of the year, and we had problems getting them done towards the end of the year again. And we were sending them off the last week of school again." Moving forward, Charlotte feels that she needs to be tougher and "find the right balance." However, she described both the first and second year as really good experiences. The first year, she was happy that they got through the project. The second year, she discovered that she needed to give her students more structure. During the second year, Charlotte also wrote up a partner contract explaining to students the steps they would be required to go through to separate from their partner. This helped to overcome the issue of groups splitting up midway through the project.

Charlotte implemented the project as an ongoing process, fitting it into her curriculum whenever she could. She explained how she returned to it regularly so that her students wouldn't forget what they had learned about their topics. She embedded "mini-lessons" throughout, and they kept folders with all of their materials. She did read-aloud/think-alouds regularly to continually familiarize her students with the format of a news article and also to have discussions around credibility and where to find sources on the Internet. Moving forward, however, she would like to do even more read-aloud/think-alouds because she believes that form of modeling is "so important". As she discussed her implementation, she explained that it is still a work in progress and she intends to do many things differently in the coming year. She wants to use the inverted triangle more deliberately to help her students structure their articles and to include their sources of information from the beginning.

Charlotte also valued the flexibility of the project and appreciated that she could pick and choose the lessons that she taught. She explained that even if teachers do not have a lot of time, they could still cover most of the important components of the project:

> I think that's important where you talk to teachers on how much time they spend. You can spend a lot of time and not get necessarily as much out of it as you can concentrated portions of time; that they can be done, some of these things, in ten minutes, part of the class, at the end of the class.

For Charlotte, those mini-lessons were useful. She used many resources from teach4scijourn.org but had to adapt several of them for her middle school students. Much of what she did is still a work in progress as she continues to learn and tweak her approach.

She also explained that she is still learning how to edit her students' work, and her approach to editing has evolved. She now uses a "workshop style" where she sits in the front of the room and the students bring up their pieces one at a time. She looks at them quickly and makes some edits and identifies areas for improvement. Using that approach, she is not taking home "150 papers every night to grade and correct." She explained that her confidence has increased because her editing skills have improved significantly. As a result, she is able to push her students to produce high-quality articles and finds it most useful to approach the edits in manageable bits of time. According to Charlotte, she does not have the same expertise as the science editor, who has years of experience, but she has come a long way and will continue to do the best that she can.

In addition to the implementation of the project in her classroom, an important step in Charlotte's transformation came when she introduced the project to other teachers,

as this reinforced her sense of competence and self-confidence in implementing the project. Last year, she worked with the National Writing Project and the SciJourn team to introduce the project to a group of teachers in Kentucky. Instead of the two-week summer workshop, the teachers attended PD over two weekends. According to Charlotte, "This was our first kind of exploration, could this be done in a shorter period of time than the full two-week training." On one of those Fridays, Charlotte got to visit a trainee teacher's classroom where she observed a student sharing with his class that he had brain cancer and would need to undergo another surgery. Charlotte explained, "That community that was built because they understood now more about his problems and why he would disappear for a month and the struggles he was going through, it was just powerful." For Charlotte, seeing the other teachers buying into the project reinforced her own transformation:

> Teachers can move from being reluctant or afraid of, or changing their mindsets when they see something that really benefits their students and benefits them as a teacher. It's not one more thing that you are adding onto them. It is something that can be incorporated and gives so much back to the students and you as a teacher; teachers can change their mindset on this, but you've got to show them how it works. You have to show them and allow them the time to try it and experiment with it and follow up with them.

Charlotte's transformative learning was incremental, occurring over the course of a few years. Her transformation began with her involvement in the National Writing Project (NWP), which influenced her to integrate more writing in her classroom. Her work with the NWP then led her to SciJourn where she was able to overcome her

dilemma of not having the necessary skills to assess and edit her students' writing. Her involvement with SciJourn also influenced her to re-evaluate her understandings of science literacy. Her story gives evidence to all ten phases of transformation, though for Charlotte, the stage of building competence and self-confidence was particularly significant as she shared the project with other teachers and witnessed the positive influence it had in their classrooms and on their teaching practices. Ultimately, there were two primary influences on Charlotte's transformation. The first was SciJourn's definition of science literacy, which challenged Charlotte to re-evaluate her own skills and her teaching priorities. The second was her students' engagement during the project, which reinforced for her that the project was "powerful."

Brian – "I'm also a bit of a rabble rouser." I first met Brian six years ago when he joined Teach for America as a high school chemistry teacher. At the time, I was in my third year as a teacher, and I was the leader of Teach for America's science learning team, where I facilitated monthly meetings for corps members who taught science. I remember Brian's enthusiasm for chemistry and his commitment to thoughtful lesson planning. He was also a firm believer in high expectations with a class motto that read "Chem Is Try". We taught in the same school district and frequently saw each other at district-wide PD sessions. In 2009, the two of us participated in a teacher researcher partnership program through a local university. That program partnered us with a researcher, whom we worked with in a lab. We also designed inquiry-based lessons derived from our lab work to take back to our classrooms. I distinctly remember Brian's project for his classroom, where he focused on developing an introductory chemistry unit that revolved around a fabricated crime scene investigation, an idea which I thought was

brilliant. Two years later, in the summer of 2011, Brian and I met up once again as we joined SciJourn's third group of teachers (Cadre 2).

I selected Brian for this study for multiple reasons, but first and foremost, his responses on the survey piqued my interest. Brian's responses indicated that he was significantly influenced by the project. For instance, in response to question 10, which asked how SciJourn had influenced his understanding of science literacy, Brian wrote: "Pre-SciJourn: Science literacy = a big vague concept that somehow incorporates vocab, reading from the textbook, teaching students to read professional science literature. Boring! Post-SciJourn: Science literacy = relevant, interesting, and a skill necessary to prepare students 15+ years out as global citizens" (Survey response, May 9, 2013). In response to question 11, which asked how SciJourn had influenced his teaching practices, Brian wrote: "Prior to SciJourn I was more focused on drilling the essential content necessary for "mastery" of objectives assessed by the state (think KIPP). Now I know that there are "bigger fish to fry." Who cares if a student knows how many protons are in Argon, if he/she cannot interpret information in a newspaper?" (Survey response, May 9, 2013). I found these responses particularly interesting because of what I knew about Brian as a teacher before SciJourn. I was familiar with his teaching style and his teaching philosophy. I also knew that Brian was an outstanding teacher. In 2012, he won teacher of the year for his school and was also the recipient of a local award for excellence in teaching science. Therefore, I was intrigued by the notion that his teaching had dramatically changed after SciJourn, and I wanted to know more. I also knew that he would be a dependable participant and would offer thoughtful insights into his experiences with the project.

Brian is a white male in his late twenties. He has been teaching for six years. At the time of this study, he worked in an urban, low-SES high school where 88% of the students receive free and reduced lunch and the average ACT score is a 16.5. The school is an international studies magnet school, serving students from 30 different countries. It has a population of approximately 1000 students and houses a sizeable English as a Second Language (ESL) program.

Brian and I met for our interviews during his summer break. We met in his classroom at his new school—also urban-- where he was busy setting up his space. Brian began the interview by explaining that his interest in science began at an early age. He spoke of being a curious child who had a fascination with inventing things. He remembered specifically trying to engineer a robot out of a cardboard box. More specifically, he wanted the robot to be able to play tic-tac-toe. His curiosity followed him to middle school where he had a science teacher who set him on the path of pursuing science. Beginning in the 6th grade, this teacher became his coach when he joined his school's Science Olympiad team, participating in interscholastic science competitions. Brian's experience with Science Olympiad, which continued through high school, was pivotal in his developing a passion for science. He spoke of one particular experience where he and his friends wrote an essay for Parade Magazine about engineering a new and improved black box that was easier to find. They won the essay contest and travelled to Washington DC and Seattle. During those travels, Brian met professional scientists and got an inside look into authentic science.

That experience validated for Brian that he was capable of "doing science." It also gave him a taste of authentic science as he got to travel and see what the real, lived

world of a scientist looks like. This set the stage for his continued involvement in science-related activities. According to Brian, “I knew, from probably sixth grade that I was going to be doing science for the rest of my life in some capacity."

Brian’s interest in science intensified during high school. During his junior year, he began an internship doing research in a chemistry lab, which was influential in his later pursuit of a chemistry degree. As an undergraduate studying analytical chemistry, Brian continued his lab experience where he became heavily involved in research on explosives detection. According to Brian, “it was cool because it was like having a grad school experience as an undergrad. I was a paid employee of a lab working on my own research project funded by the Department of Homeland Security."

Brian began touring graduate schools during his junior year and was on the path to get a PhD in analytical chemistry when he began questioning his future. Though he enjoyed research, he could not see himself doing it as a career. It was that same year that he began coaching a Science Olympiad team at a rural school and “realized, that man, I can really see myself doing this science teaching thing long term." From there, he decided to pursue teaching, but switching his degree to chemistry education would have required another three years of schooling, so he looked for alternative options, which led him to Teach for America. He was accepted into the program during his senior year and began his teaching career the following summer.

As a teacher, Brian thrives on creating a student-centered environment where he relies heavily on the modeling method of teaching chemistry. The modeling method requires that students observe a phenomenon, develop their own explanations for it, and then defend and debate their explanations with their peers. According to Brian:

> rather than me telling, it's more of them discovering science. It takes a lot longer. It requires me to be very hands-off at times. And it can be really frustrating with the naïve conceptions that are presented, but in the end, it provides for a much more powerful learning experience.

He described a good day of teaching as one where students do 95% of the talking and he only does 5%. Initially, his students get frustrated because he does not directly answer their questions but instead probes their ideas. Eventually, however, that frustration leads to independence, which, according to Brian, "is, I think, the most powerful thing a teacher can give a student is the understanding that they can be independent even in a rigorous science classroom."

Brian described his school environment as dysfunctional and tells a story of being given a broken overhead projector and one piece of chalk on his first day of school. He also described himself as a "rabble rouser" when it comes to using test scores to determine progress, so he pushes back against using "faulty content assessment" to drive instruction. Due to his school environment, he was low on resources but he also had the freedom to implement his own curriculum and to teach the way he wanted with little supervision.

He also sought out his own PD because the workshops provided by his district were "really bad". He began attending conferences his first year of teaching and found an appreciation for being part of a greater science education community. He enjoys coming back from a conference with a useful bag of tricks to improve his teaching. He also engages with other teachers via Twitter.com and described most of his PD as being informal where he picks up "little tidbits of things" that make life better in his classroom.

In describing his best PD experience, Brian told the story of another Teach for America chemistry teacher who served as his mentor:

> Somehow, he, well he ended up here to go to medical school but was able to come into my classroom and teach one of my classes. And that was the best PD I ever received because I saw that he was able to do exactly what I wanted to do with my exact set of kids. So no longer were there excuses….that helped reiterate for me that it is something possible that can be learned; how to be an effective science teacher.

Brian explained that his strengths as a teacher are planning and executing student centered learning experiences. In describing his weaknesses, however, he said that he struggles to utilize those experiences "to get to the upward echelon of rigor that you might see at a suburban school." He gave Advanced Placement (AP) chemistry as an example and told of his frustration with resorting back to teacher-centered methods because there is so much content to cover. He described it as a "big mess" and attributed his lack of success with teaching AP to his decision to pause his chemistry teaching career.

His decision to move on from teaching chemistry landed Brian in a new position where he now oversees a Makerspace at an arts-centered charter school. He described it as his "dream job" and a culmination of everything he's been working towards as a science teacher, a space where the focus is on tinkering, building, and engineering things. According to Brian, "it's all the joys of having a student-centered chemistry experience without the annoying parts like having to evaluate students with letter grades."

Brian's SciJourn story. As we sat down for the second interview, Brian began by talking about his ongoing struggle to incorporate science literacy in his chemistry classes. Prior to participating in the SciJourn project, Brian perceived science literacy as being able to read a science textbook. He struggled to implement teaching science literacy because he had so many students who were reading significantly below grade level. Thus, he was unsure how to bridge the gap between their reading levels and the textbook, so he relied on breaking the material down into daily vocabulary words and then drilling the material. Though he knew these tasks lacked authenticity, he did not have alternative instructional methods. When he learned of the SciJourn project, he was particularly interested in learning to teach science literacy in a way that tied it to an authentic task, like writing science news.

***Defining science literacy*.** For Brian, SciJourn's definition of science literacy was pivotal. SciJourn defined science literacy as the skills students will need to successfully deal with the science-related issues they may encounter 15 years beyond high school graduation. Brian felt that SciJourn's definition contextualized his mission as a science teacher and gave him a vision for his classroom that helped to focus his teaching on a daily basis. According to Brian, his understanding of the skills that he wants his students to walk away with changed dramatically as a result of the project, which forced him to reconfigure his teaching priorities:

> I want them to be ready to critique, analyze, form their own opinion, on science issues 15 years out. You know, I know I'm using that from SciJourn, but I think that that's the most valuable skill students can have, because they're going to be bombarded with it, with climate change, you know, even their own personal

> health. They need skills to be able to condense the information provided to them and then form their own opinion on it and form that opinion using multiple, credible sources.

This emphasis on teaching students to find multiple, credible sources of information required that Brian spend intentional time teaching his students to do research. To do so, he relied heavily on the modeling method, using read-aloud/think-alouds. He also modeled credibility by going to "sketchy websites". He told a story of finding a website that promised to help individuals make thousands of dollars in a day. It had ads from CNN, MSNBC, and other visuals that made it look credible. He showed students how they could quickly figure out that it was a scam by clicking around on various links. According to Brian, he learned that research strategies need to be explicitly taught, even basic skills such as using a search engine:

> There are so many teachers who I've heard complain that my students can't do research. And I think that the SciJourn method offers a pretty cool way to integrate the research skills that will be applicable, not only for writing SciJourn articles, but also for just any general research.

Brian also began focusing more on reading and writing in his science classroom. He described how he began to realize the value of having students read and then reflect, something he would never have implemented in his classes before SciJourn. He also explained that he had always had writing assignments in his classes but had never taught students how to approach them. According to Brian, his mentality towards writing shifted and he now considers himself a writing teacher:

> I'm sure my mentality was, 'Oh, they'll learn, they learned how to write in English class, and so then, what I'm assessing is the science.' Well, that's bogus, you know. You have to teach the writing skills because there are so many different types of writing, and the way a student writes in a science class is much different than the poetry or short stories or five paragraph essays that a student will be writing in a writing class.

Engagement and authenticity. As he began teaching the genre of science journalism, he also developed an appreciation for its authenticity. According to Brian, "there's so much value to having students publish something that they know other people will read…I'm confident that student writing increases in quality when students know other people besides the teacher are going to be reading it." The project also led to increased student engagement. He explained how "it's very rare in school that students get to have complete control over what they're learning." Therefore, allowing students to choose their own topics was essential to this increased engagement. Brian described the rarity of watching his students work readily on the computer for over an hour. He also explained that "seeing when students are thinking about a project outside of class time, that really shows that it's impacting them."

Professional development. For Brian, his experience with SciJourn's PD was also significant. He explained that when he began the two week summer workshop he initially felt uncomfortable because the PD "felt somewhat unstructured." He was accustomed to presenter-driven workshops and was used to being "talked at." After a day or two, he realized that SciJourn's PD was intentionally structured to build community so that the teachers could get to know one another as a cadre and discovered that he was

able to learn more in that setting. He also appreciated that the model was teacher-centered and felt that having to write his own news article was pivotal. It allowed him to empathize with his students, and he found he was able to connect to his students in a unique way when it came time for them to write articles for his class.

According to Brian, he had never written something that he knew was going to a larger audience. He was motivated because the article would be viewed by many people and also that he would be able to use it as a teaching tool in his classroom. He wrote his article on radon because he had recently purchased a home where radon had been found. He had never written in a journalistic style before and found that learning the process made him more literate in how he reads news.

Brian also valued the community that SciJourn built. He formed friendships with a few of the teachers and the ongoing PD sessions often felt like a "reunion." He appreciated having the opportunity to network with teachers from around the region and to learn what was happening in schools outside of the city. He also found that the SciJourn community provided a level of accountability and collaboration where he could learn from other teachers:

> Anytime I go to a PD, it's just a nice refresher and re-motivates me to – re-motivates me that what I'm doing is okay and now it's time to make it better...there was one PD and it was all about infographics...and so after that, I implemented infographics daily during my SciJourn project.

That community also provided Brian with a sense of support. He explained that if he ever felt like an aspect of SciJourn was unapproachable or was having difficulty, he could reach out to someone in the SciJourn community and ask for help.

A new story to live by. Like most teachers, Brian has multiple stories that he lives by. Prior to SciJourn there were two prominent plotlines that diverge in his teaching story. One of his stories to live by was that he taught in a struggling school in a struggling district. The other was that he established a culture of high expectations in his classroom and actively pursued rigor in teaching science content despite working in this "dysfunctional" school system. One of the ways he lived out that story and pushed against his school's dysfunction was by creating a student-centered learning environment, which he perceived was one of his strengths.

Prior to SciJourn, Brian believed that maintaining rigor meant that his focus should be on content. Within that perspective, he viewed science literacy as being able to read the textbook. Participation in the SciJourn project, however, changed his story to live by as it gave him a new way to conceptualize science literacy, which resulted in a reconfiguration of his teaching priorities:

> I've said this a lot, but literacy was always this big obstacle to tackle that I didn't really know how to approach, and now I have a set of surefire methods for integrating it into my classroom...I now have the mindset that this is something important in a science classroom, much more important than drilling electron configurations or Bohr model. These skills that students have will really take them more than just within the scope of the course.

This new story to live by aligned with Brian's plotline of having high expectations for his students. He told a story of his mom sending him the link for a program implemented in New York City where students write raps to learn science. Results showed that students who participated in the program performed better on tests. His mom sent him the link

shortly after his participation in SciJourn, thinking he might find it helpful. His response, however, surprised her as he questioned if these raps were helping to prepare the students to think scientifically 15 years out, and he argued that the purpose was around drilling content rather than teaching actual science. According to Brian:

> My gut said, 'Sure, while it's great to see urban students being excited about learning, I think that that's kind of a cheap trick to do so.' And I think you can do so at a much deeper level with something like SciJourn. Imagine if these students instead of rapping were delving into issues that affect them and, you know, taking control. Like my students are - you know, like all these SciJourn students are doing. I think that is better suited to prepare them for success as either a scientist or just a citizen.

Ultimately, Brian's experience with SciJourn provided him with an authentic, purposeful way to bridge teaching science literacy and higher order thinking, while also influencing him to reframe his teaching priorities around preparing his students for the future rather than focusing solely on chemistry content.

Brian also explained how participation in the SciJourn project influenced his personal story to live by making him more literate in terms of his own consumption of news:

> After doing the SciJourn training, I now listen to NPR in my car. Before SciJourn, I couldn't stand listening to it. I didn't understand why people would want to listen to people talk on the radio, but it's made me a much more newsworthy person.

He went on to explain that he now consumes news not only as a citizen but also as an amateur journalist. Because of SciJourn, he now understands the structure of news articles and how they show the reader that information is credible. He also attends carefully to the kinds of questions that interviewers ask and also how they bridge to follow-up questions. Critiquing news from the journalistic perspective has become a hobby for him as he pays close attention to the language that is used: "SciJourn taught me that being clear with language is very - clear and concise with language is very important." According to Brian, he could see himself writing another news article and submitting it somewhere as a citizen/scientist.

After his participation in SciJourn, Brian's story to live by continues to have two prominent plotlines. The first plotline has not changed as he continues to teach in a struggling school. The second plotline, however, was altered. While he continues to pursue a culture of high expectations, his notion of rigor is no longer based in content, but rather, the pursuit of lifelong skills that will enable his students to be scientifically literate.

Transformation. As seen in his new story to live by, Brian experienced transformative learning through participation in the SciJourn project. In order to understand how this transformation occurred, it is useful to look for Mezirow's phases of transformation within Brian's experience.

According to Brian, he developed an interest in the SciJourn project because he was drawn to an "authentic" approach to teaching science literacy. At the time, Brian was experiencing a disorienting dilemma in his teaching. As a teacher whose story to live by was based on creating a culture of rigor, Brian was struggling to find a rigorous

way to embed science literacy into his chemistry courses. His method of teaching science literacy, which relied on teaching and drilling vocabulary, did not align with his story to live by. As such, Brian was compelled to explore other avenues to teaching science literacy in an attempt to preserve the culture of rigor in his classroom.

When Brian began his SciJourn training, he experienced a shift in consciousness that was triggered by SciJourn's innovative definition of science literacy, which challenged his assumption that science literacy was about reading the textbook. This shift in consciousness forced Brian into a place of critical reflection where he began to re-evaluate his teaching priorities. With a new set of teaching priorities, which were centered on the idea of preparing students to deal with science related issues fifteen years out, Brian had to revise his instructional approach. SciJourn gave him a "set of surefire methods" for integrating science literacy in his classroom, and he began to explore ways to embed SciJourn concepts into his teaching. This new approach required that he take time to teach his students how to evaluate and find multiple, credible sources of information, and also to teach them how to write and structure a news article. For the first time, Brian began to identify as being a writing teacher.

The summer institute was the vehicle for Brian's transformation. It is there that he created a plan for implementation of the project and developed the skills necessary for teaching his students to write science news articles. For Brian, the experience of writing his own article was integral to this process as it gave him essential insights into what his students would go through when writing their own articles. His students' engagement was also influential and played a significant role in his implementation. When he saw his

students becoming invested in the project, it was a motivator to work out the kinks. He was also impressed by the authenticity of the project. According to Brian:

> If I'm going to give an elevator pitch to somebody about why SciJourner is important, I would say I have a student who published an article and it now has 13,000 views. You know, that – imagine having a student write something and 13,000 people view it. That's incredible.

Implementation. To implement the project, Brian relied heavily on the resources on teach4scijourn.org. He downloaded all of the lessons and arranged them and modified them for his students. He also relied on the project's book, *Front page science: Engaging teens in science literacy*, as a resource to re-familiarize himself with some of the teaching strategies and questioning methods. As Brian began to implement the project in his courses, he primarily used the modeling strategy and regularly did read-aloud/think-alouds, which he believes are critical for developing students' literacy. He began by reading the *SciJourner* newspaper with his students. From there, students began to pitch ideas for topics. According to Brian, it was a very student-centered process where students guided their own research and writing. He also used the Science Article Filtering Instrument (SAFI) (see Appendix J) to help show students where they needed to be cautious of stereotyping and plagiarism.

During his first year, Brian opted to implement the project as a "blast" during the two weeks at the beginning of second semester. To begin the project, the students were given introductory surveys and worked to focus their topics. From there, they moved into examining multiple, credible sources where he deliberately taught students to navigate web searching and how to identify credible sources of information. He also printed out

infographics, had his students analyze them, and then they had to write down three things they learned or found surprising. That analysis process was helpful because students would often come upon infographics related to their topics while doing research. In structuring the writing process, Brian used the inverted triangle and focused heavily on using attributions in writing. All of his students were required to write a rough draft, and then Brian edited all of those rough drafts and gave them back to his students so they could begin their revisions. He did not send drafts to the editor until students had made the changes that he suggested. Brian described his approach to the project:

> Everything that we did – literacy was implemented as a whole system. It wasn't bits and pieces like I was doing before. So having students find a topic they're interested in, researching that topic, putting it into teen-friendly language, having the relevance piece there, and then also seeking out multiple, credible resources. The literacy, there is a line to preparing students for science 15 years out; and having that vision, which was provided by the SciJourn training, really helped me to focus what we were doing on a daily level.

Brian knew that the first year of implementation would involve a learning curve as he worked to adapt the project to his classroom context. The first year, he thought the project would be a good way to pull students in after winter break. However, he found that it was difficult to get his students engaged in general chemistry content after SciJourn, so during his second year, he revised his approach and opted to do SciJourn as a blast at the end of the first semester. However, he found that many of his students disengaged from their topics over the break, so they lost momentum for editing and resubmitting. Moving forward, he would still opt for a first semester blast but would

allow enough time to edit before the semester ended. Brian also struggled to implement the project with some of his struggling readers. Many of his English language learners (ELL) would decide on a topic but then have difficulties finding accessible websites, so he allowed some of his students to do a caption project instead of writing a full article.

It was during his first year that Brian also had a student whose article was close to being published when the editor realized it had been plagiarized. He described the incident as "tragic" and was disappointed that he did not catch it before he sent it to the editor. According to Brian, "I remember getting this on a Saturday, and all I thought about Sunday was how I was going to approach the student because she was such an all-star student in general chemistry." Most disappointing for Brian, however, was that the student was more than capable of writing original content and chose not to. Based on that experience, during his second year, Brian spent more time modeling how he finds plagiarism by highlighting text and then putting it into a Google search. He found that it was more effective to show his students how easy it was to catch plagiarism rather than just telling his students not to plagiarize.

These changes in his implementation of the project give evidence to the last few phases of transformation where Brian tried out SciJourn's approach. Over the course of a couple of years, he made the project his own as he built confidence and modified his implementation according to his experiences and his specific contextual needs.

In Brian's case, there was evidence of all of the stages of transformation, with the exception of stage 2: self-examination with feelings of fear, anger, guilt, or shame. It is possible that this stage was combined with his disorienting dilemma or also, that it was embedded as part of his critical reflection. It is also possible that he may have had these

feelings but did not express them in his interview. Brian's movement through the phases was also not linear, particularly as he moved back and forth revising his approach to using SciJourn in his classroom.

Brian's transformation was epochal, specifically triggered by SciJourn's summer workshop where he was introduced to and began to internalize SciJourn's principles and concepts. The transformation was then solidified as he worked to adapt the project and make it his own. While there were multiple influences on his transformation, SciJourn's definition of science literacy was the most significant as it was the catalyst that triggered a change in his thinking and thus, his story to live by. Though participation in SciJourn influenced a change in his teaching identity, it also reinforced his plotline of having high expectations because it gave Brian an authentic, rigorous way to embed science literacy into his teaching story.

Johnny – "I love atoms." I first became acquainted with Johnny through SciJourn's professional development sessions. Johnny was a participant in the second group of teachers to go through the program (Cadre 1). Johnny and I also took a course together at the University of Missouri-St. Louis, where we explored SciJourn's principles in more depth. It's during that course that I got to know Johnny and his teaching philosophy.

Based on Johnny's survey responses, he was moderately influenced by his participation in the project. I selected him to participate in this study because his survey responses, though conveying some influence, were not overly specific. For instance, in response to question 4, which asked how SciJourn has influenced his teaching practices, he wrote, "I incorporate more writing and researching in my lessons." He also indicated

in his response to question 2, which asked how his implementation had changed, that his approach to using SciJourn had evolved. He wrote: "At the beginning I tried to incorporate SciJourn article writing into my classes, but that was difficult with block scheduling and students' work ethic. I found that using infographics allows students to still do science researching and writing, but in smaller bursts. I was able to better incorporate infographics in my curriculum." Based on these responses, I wanted to know more about this evolution of his implementation of the project and also, to see if I could get more details regarding his perceptions of the project.

Johnny is an African-American male in his late thirties. He has been teaching high school science for nine years in a large, suburban school district. His school has roughly 2,200 students, 45% of the students are African American, 50% are white, and the other 5% are either Asian, Indian, or Hispanic. Forty-six percent of the students qualify for free and reduced lunch. The average ACT score at the school is a 19.

Johnny and I met for his interviews during the summer break and completed his interviews in my office on campus. We met during the evenings because he was starting a new administrative position in a nearby school district. During his first interview, he explained that his interest in science started as a child. He described himself as a "nosy little kid" who was always interested in learning how things worked. He spoke of going to the library as a child and checking out books on how to build lasers and trying to build them at home even though he had none of the materials. He explained: "I've always been interested in science. I've been interested in nature. I was one of those little geek kids that had a chemistry set when I was little and did little experiments with those. But yes,

and it just lasted all the way until I got –I graduated from high school. Always interested in science because it lets you know about your world."

During the fourth grade, Johnny was placed in a gifted program. He attributed that program to getting him excited about school. Up until that point, he "just showed up". He did his work and passed his classes, but he was not engaged in the learning. Once he was placed in the gifted program, something clicked for him and he wanted to do more. "Being in that program really, really got me excited about school because now we're doing things that I didn't know how to do before. And so we were learning about geography. We were learning how to work with computers in the mid-80's. Doing stained glass and all this variety of different things."

While the gifted program was pivotal for Johnny's school experience, his interest in science stemmed from his home life. Both of his parents shared an interest in math and science. He recalled learning about science from his mom's nursing books and learning math from his father's books, "that's where I got my interest in science; more from my family than school."

When Johnny graduated from high school he went to college with the goal of becoming a scientist. He got his Bachelor's degree in biology and continued into a PhD program in molecular biology. Once there, however, he began to question a future spent working in a lab. He explained that the tediousness of the lab work turned him off. At the time, he was also working as a teaching assistant for a biotechnology class for non-majors and found that he really enjoyed helping his students understand science. That was a turning point for him, and he decided to master out of the biology PhD program and get his teaching certification instead.

Johnny described his entry into teaching as challenging. His first year in his school, he did not have his own science classroom, but instead, taught off a cart that he moved from room to room. Since he was teaching primarily in communication arts and social studies classrooms, he was limited in the kinds of science activities he could do. Consequently, he relied on lecturing and worksheets for the bulk of his instruction. By his third year, he was finally teaching in his own classroom and started incorporating more experiments, one of his favorite parts of teaching science.

Johnny explained that his ultimate goal as a teacher is to prepare his students for life outside of school. Chemistry, according to Johnny, helps students to understand how their world works so he strives to make the content relevant to them. He explained how he wants his students to see that chemistry is practical, "whether it's something that they eat or are cooking, how their body works, why do they do certain things with their cars in the wintertime versus summertime, I always relate it back to what I'm teaching them."

Johnny also pointed out that his science class may be the last science class that his students take, so he prioritizes teaching his students how to understand scientific information. Reading science, according to Johnny, has always been integral to his classroom. He described a good teaching day as:

> a day when I see students making connections between what they are learning and other aspects of their lives. A good day to me is when they're asking questions about the topic and relating it to something else…I like my students working. I like them engaged. I like them excited about the class.

Johnny described his students as the average student in the school. Aside from one elective course, he has never taught advanced students. Instead, he teaches the

special education students, the English as a Second Language students, and the students who struggle to succeed in school. His population of students heavily influenced his teaching style, making his classes more student-centered. He explained that he had to accept that his students are not like him:

> when I was in high school, when I went into a science class I was interested because I was just interested in the subject. You want to talk to me about atoms? Cool, I love atoms. Talk to me about them. But these kids, the kids I had, in their day-to-day lives they really don't care what stuff is made out of. And so I had to make it relevant. I had to make it interesting. I have to bring it to them; to where they are.

Consequently, he explained that he occasionally struggles because his tendency is to tailor his lesson to the way he learns, and he often has to step back and determine the best way to present the material so his students will make the proper connections.

According to Johnny, his school district values education but is also in transition as it copes with a changing, more diverse student population. He described most of the district-level PD as irrelevant to his particular needs. According to Johnny, "the only PD where I really felt that I got something from was the PDs that I chose to go to." He also spoke of his desire to continuously improve his teaching craft and explained how he is always retooling his lessons. He explained that he's never content, and every year he's modifying and changing his lessons.

His desire to continually learn and challenge himself led Johnny to a new position in a new school district. In his new role, he does not work as a classroom teacher but is a Science Technology Engineering and Math (STEM) career pathway coordinator. In this

position, he works closely with teachers to integrate more science into their elementary instruction and to strengthen and refine the district's career and technical education program. As of this moment, he is returning to the classroom in his old school because of the lack of job security in the recently dissolved district where he served as coordinator.

Johnny's SciJourn story. When I asked Johnny how he became involved with SciJourn, he explained that his interest in the project stemmed from his early teaching career. When he first started teaching, he felt that it was important for his students to know how to decipher scientific text so he would have his students read articles from a newspaper or magazine to help them learn science content. When he heard about the SciJourn project, he was interested because he had always felt that teaching science literacy should be a priority.

***Defining science literacy*.** Johnny has always been very mindful that his chemistry course was the last science class that students were required to take, so he's always felt the need to prepare his students for the future. In that context, he viewed teaching science literacy as, "making sure that they knew how to make sense of science text." According to Johnny, he was really focused on decoding, "Can you decode the text? Can you look at this article and know what it's saying, know what it means or frame it in an overall picture?" After participating in the SciJourn project, his thinking around science literacy changed significantly. Rather than focusing on decoding, he explained how he began to prioritize having his students evaluate sources of information:

> I learned a lot about science literacy, especially considering how to identify good sources. When I had students read articles in my class, I chose the articles – you know, I scanned it and made sure it was something that was credible and so forth.

> So, they never really had to think about that….that was something that I never really considered as part of our instruction.

As a result, Johnny began to think about how to teach students to identify multiple, credible sources of information. He also took away a renewed urgency towards preparing his students for the future:

> They need to be scientifically literate. They need to be able to take in new knowledge, research new scientific discoveries and new information, and be able to see how it will affect them, and whether or not the claims being made are valid.

Johnny's perception was that most people think of literacy as having students read a textbook. This view, according to Johnny is antiquated, and he felt that SciJourn provided a more futuristic view that emphasized teaching students to evaluate scientific information found on the web, "They need to be able to get information from the web and say, 'Hey, I read this from the web and I can't take this as full-fledged truth. I need to evaluate this." He said that SciJourn was very different from the literacy and writing initiatives that his district usually implemented. Typically, students were given writing prompts or writing directives, which did not require students to analyze what they were producing. SciJourn, on the other hand, required that students analyze "how they were writing, what they were writing about, and whether or not that information was a valid source of information," an approach that Johnny believed, had more value.

Johnny appreciated that the project gave him a way to teach his students how to be "better researchers." Though he was always interested in teaching his students how to find information, he did not focus on the digital component until SciJourn changed his perspective. He explained that he's more aware now that his students are getting their

information from different kinds of sources. When he was young, researching meant looking at print sources, all of which had been filtered through an editor. Today, his students are relying more on digital information, either from the web, their phones, or social networking sites. However, there is not a formal place in the current curriculum where students are explicitly taught to evaluate digital information. Consequently, Johnny now thinks of teaching science literacy as focusing on the "digital information dome":

> It's not just about reading about science, it's about understanding where that information is coming from and understanding how to sift through – if you do a Google search and you search for a topic and you come up with 500 websites. It's learning how to sift through those 500 to see which one is the best…That becomes a more valuable aspect of scientific literacy and definitely that's one of the things that SciJourn helped me to teach my students.

Engagement. Johnny was also inspired by his students' engagement during the project. When he first introduced it, many of his students started "moaning and groaning", but once they began selecting their topics, their engagement increased and they became very interested in researching for information. He observed that many of his students who had not expressed any interest in science got excited about the project, "They were willing to talk about something scientific because it was something that was interesting to them. I think that was one of the biggest successes." He also observed that over time, his students started talking more about "credible sources of information," and he found it exciting to see them having those conversations on their own.

Professional development. SciJourn's PD was particularly important to Johnny's experience. He was initially surprised that he was asked to write his own article during the summer institute but found that he really enjoyed the process. He appreciated that he was able to write about something that interested him, and he chose to write an article on the Xbox 360 and why earlier models kept overheating. The revision process was also significant because he had never really considered revising his writing before.

The genre of science news was also new to Johnny and he appreciated that the SciJourn team helped to scaffold that learning process and taught him explicitly how to structure the writing, how to guide students through the research process, how to edit, and how to approach revision. He also felt that the PD valued his teaching context and respected his individual needs:

> They gave us PD on how to do it; not just "Do this," but "Here's how you can do it and here's how you can put it into your classroom and into your curriculum" so that it's actually a good fit and not something that you've added on and tacking on extra…there was great care in making sure that it fits within your curriculum, fits with what you're doing in the class, not just adding something extra, it's enhancing your instruction.

He went on to explain that most of the literacy-focused PD he has attended is "English-based," meaning that it was focused on voice or mechanics and was geared towards the English department. According to Johnny, when he sat through those PDs, he never felt like the content was relevant to his science classroom. With SciJourn, however, the writing was more relevant, and he felt that the writing style could be applied to any subject. Because of that, he felt that he was taught strategies that he could really take

back to his classroom and use. He also appreciated that the project was flexible, and he could pick and choose which aspects he implemented:

> One of the things they stressed was that you could do as much or as little as you needed and you could modify it according to your class…So, the fact that the program allowed you to do what you needed to and fit it to your class made it much more reasonable or made it much more valuable for me as a teacher.

For Johnny, another important piece of the PD was the SciJourn community. He enjoyed working with teachers from other schools and districts and appreciated how they shared their ideas and lessons with each other. He also found the community particularly helpful as he struggled to implement the project during his second year. During PD meetings other teachers shared their struggles and offered advice on how to overcome them. According to Johnny, he was hard on himself and those meetings made him feel better; he realized the "pitfalls" he was experiencing were not unusual, and he often came away feeling inspired to keep trying. He felt that the community was very supportive and appreciated the "guidance" that he received. He explained that oftentimes, PD workshops do not offer any guidance for teachers once they are back in the classroom. SciJourn was different because of the high level of ongoing support:

> There were people there all along the process, during the PD and afterwards saying "Hey, let me help you. If you're having problems, I can help you in doing this, I can help show you some techniques, I can give you some pointers." That's what made a difference: guidance.

A new story to live by. Prior to participating in the SciJourn project, Johnny's teaching identity had two interconnected plotlines. The first was that his "ultimate goal"

as a teacher was to prepare his students for a life beyond school. Within that story, Johnny placed emphasis on teaching the last required science course at his school and made it his focus to create links between science content and real life. Because of that, he had to find creative ways to keep his students motivated and engaged, which he felt was an ongoing struggle. As he said, "I have to bring it to them; to where they are." The second plot that emerged in Johnny's story was that he taught "textbook science" and was tied to his school's curriculum. Also within that storyline was his tendency to tweak his lessons because he wanted to try new things and was never satisfied "doing the same thing over and over".

Johnny's story to live by, however, was revised based on his experience with the SciJourn project. The project influenced Johnny to re-evaluate the resources that he used in his teaching. He explained that he now thinks about everything that is used in the classroom differently than he did before. He also no longer feels tied to a textbook but relies more heavily on digital resources:

> Me, I could teach a class and I don't need a textbook. I really don't need a textbook because I know how to find resources to help me to teach the subject. I'm not tethered to a book anymore, way less than I was.

He now goes online to find resources and information to teach his students certain concepts, and he feels that he's a better teacher because of it. He explained, "I think it's actually better in many ways because the information that you find online is usually way more relevant to the students than what they ever find in a textbook; it's more interesting to them." So while Johnny still follows his school's curriculum, his new story to live by is characterized by a changed set of teaching tools, where he uses a wider variety of

sources and information, which are also more engaging for his population of students. In many ways, the project challenged him to think beyond textbook science and to utilize "more relevant and interesting" information. He also finds that he has become more reflective and more cautious about what he reads, paying more attention to sources of information in his personal life, which is a skill that he hopes to pass on to his students.

While Johnny's participation in the project changed his story to live by, it also strengthened his belief that he should prioritize preparing his students for life beyond high school, and as he explained, he now has better tools to accomplish that. He explained that the project helped to make his students more "metacognitive" because in order to write an article or create an infographic, they have to evaluate and synthesize information.

Transformation. Johnny's changing story to live by points to transformative learning. His disorienting dilemma came during the PD when he realized that his idea of teaching science literacy really meant teaching his students to decode text. Johnny had always prioritized science literacy in his teaching so he began to self-examine when he realized that his approach to teaching science literacy was missing an essential piece, "I didn't have that digital component in the past, and this really brought it to my attention." SciJourn's definition of science literacy and the emphasis on teaching students to find multiple, credible sources of information influenced Johnny to reflect on his assumptions around teaching science literacy. As his thinking began to shift, Johnny moved into planning for his implementation of the project. According to Johnny, the summer institute was critical because it taught him how to write a science news article and also changed his thinking around revising writing, which is something he had never done before. The

training also equipped him with tools to guide his students as they learned to evaluate the credibility of digital information.

Implementation. While the summer training was pivotal for Johnny, implementing the project in his classes did not go smoothly. When he returned to this classroom after the summer institute, his goal was for his students to write articles. Originally, he planned for his students to do a piece of the project each quarter. The first quarter they would write rough drafts, the second quarter they would work on revisions and so on. However, when he tried to implement the project, he found it very difficult because he only had 15 computers and 27 students in each class. So his original plan, to have all of his students working at the same time, did not work and it took much longer than he expected. That year, he was also teaching chemistry for the first time and had to familiarize himself with a new curriculum. Therefore, it was difficult for him to embed the project as he was trying to find his way around teaching a new content.

His implementation did not start until the end of first quarter and at the end of the first semester, all of his students were finished with their first drafts. According to Johnny, that's when things "really fell apart" because at the start of second semester, many students' schedules were changed so he lost many of his students and had several new students coming in who had not written rough drafts. Based on that experience, he decided that in the future, he would need to try to complete the entire project in one semester.

During his second year, he was given a schedule where he taught three different subjects. He described the start of that year by saying, "I was almost in survival mode for a half a year trying to get up and running. So I think the school dynamics really kind of

hurt the article writing aspect that I wanted to do." As a result, he did not have his students write articles that year, but instead, incorporated SciJourn principles into his classes. When his students would write lab reports, he would have them write a rough draft and then he would edit them and have the students revise their writing. He also had students examining and evaluating their sources in greater detail. In that way, he tried to embed some of the same skills that they would touch on if they were writing a news article.

In his third year, he moved to having his students create infographics in his chemistry classes. He felt that the infographics were less time consuming, which was important because his school had switched to a block schedule and he only saw his students every other day. He explained, "it seemed like every second of the day seemed really valuable in terms of making sure I get in the content." Having his students focus on infographics, however, allowed him to integrate SciJourn's literacy practices in a more time efficient way. He also found value in having his students focus more on graphical representations of numerical data because they had difficulties in analyzing and interpreting visual data. The infographics, therefore, provided a way for students to research and also work with "making data meaningful."

He built the infographic project around the periodic table. His students worked in pairs and were randomly assigned an element. He opted not to have them select an element of their choice because he did not want students to only research common elements such as oxygen and carbon. In that way, he was able to get students to research some of the more obscure elements. Students were asked to find relevant and interesting information about their elements and then create an infographic showing what they

learned. Overall, he was very pleased with the infographic project because he saw his students researching their elements and making connections to their lives. He explained:

> They were seeing how a simple element could be extremely important because I had students like, "Oh well, I'm anemic and I'm doing iron and now I'm finding stats about how anemia affects people and the percentage of the population that may have this disorder." And now they're connecting chemistry to their lives and the lives of people around them right?

For Johnny, seeing those connections was pivotal in his transformation. After struggling for two years to implement the project, he finally found an approach that worked and made him feel successful. In devising an infographic assignment around the periodic table, Johnny took ownership over the project, adapted it to his specific context, and made it his own.

Johnny also used read-aloud/think-alouds throughout the three years. He described how he would use his planning time to find interesting articles that related to their content, and he felt that the read-aloud/think-alouds were really useful for making science topics more relevant and interesting to his students.

Johnny's experience with the SciJourn project showed evidence of all ten phases of transformation. His movement through the phases was not linear as he worked through his struggles with implementation, moving back and forth between trying a new approach and then revising his course of action. His transformation was incremental as it evolved throughout his three years with the project. His transformation was solidified after he developed the project using infographics and finally felt successful in his implementation. For Johnny, the most important influences were SciJourn's innovative

definition of science literacy, which challenged his previous assumptions, and also the sense of community and support that he experienced during the PD. Together, these influences equipped Johnny with a new set of tools that altered his approach to teaching and changed his story to live by.

Denise – "I'm very particular." Denise was a participant in SciJourn's second group of teachers (Cadre 1). Aside from seeing her at SciJourn's PD meetings, I did not really know her. I selected her for this study strictly because of her responses on the survey. Based on her responses, Denise was placed in the slightly influenced category. She was one of the only teachers who shared criticisms of the project in her survey responses, and unlike most of the other teachers in the slightly influenced category, she was willing to be interviewed. Many of Denise's responses on the survey were very brief and did not give much insight into her perceptions. For instance, in response to question 11, which asked how SciJourn influenced her teaching practices, Denise responded "more reading." Similarly, in response to question 15, which asked about the weaknesses of the PD, she wrote, "Follow-up tended to drag during the second year." She also indicated that she was no longer implementing the project in her classes. Based on her responses, I was interested in learning more about Denise's experiences with the project and hoped that I could get deeper insights through the interviews.

Denise, a middle-aged, white female, has been teaching high school science for 16 years. She teaches in a large, high performing, suburban school district where the average ACT score is a 23. Her school has almost 1,300 students, 85% of whom are white, 10% are African American, and the other 5% are either Asian, Indian or Hispanic.

Her primary subject is chemistry, but she also teaches an Authentic Science Research course for advanced students, where she implemented SciJourn.

Denise and I met for her interviews at the end of her summer break. We met in her classroom where she was busy preparing for the coming school year. According to Denise, she always loved science but is not quite sure where her interest in science came from. She referred to herself as a "why type person", who was always curious and asked a lot of questions. As a child, she loved school and had "great" teachers. She was a gifted student who excelled in science but struggled with math. Her favorite teacher was her high school biology teacher, who made the content hands-on and kept it interesting. When she entered college, Denise started off as a nursing major but later decided to stick with the sciences rather than pursue nursing, a decision that she sometimes regrets "because they get paid really well." After her sophomore year, she chose to major in chemistry rather than biology. She did well in chemistry and surprised herself because she excelled more in college than in high school. She also found that she enjoyed working in the lab and took a part-time job doing lab prep.

After graduating, Denise took a job in chemical sales but quickly learned that she was not a "sales person." She left that position to work as a lab chemist for a local chemical company, a job that she really enjoyed. According to Denise, there are still days that she thinks "Maybe I will go back and work in a lab somewhere." Though she enjoyed the work, the hours were long, and she would often put in 45-50 hours per week. After she had her first daughter, she reconsidered her career path:

> After I had my oldest daughter, I did that for about a year and thought, 'wow, this is not really how I anticipated being a mom', when I would get her up in the

> morning, take her to the sitter and then bring her home at night and put her to bed, basically."

That was the catalyst for Denise to pursue teaching, a career that would give her more time with her children. It took her a year to get her certification and then she began teaching chemistry at a Catholic high school where she was the only chemistry teacher and had to learn everything on her own, without any classroom support. She enjoyed the students, however, and found that she really liked teaching. After a couple of years, she and her family moved across the state line and she did not renew her contract.

During that time, she had her second daughter and decided to return to school to get her Master's degree in Environmental Science. She went back to school full-time and did not work for three years. According to Denise,

> I loved it because I really wanted to have that experience of researching and, you know, learning and hands-on stuff…that was important to understand that whole process of, how do you take an idea and run with it, and learn about it and experiment, and all that kind of stuff.

Pursuing her Master's degree led Denise to teach entry-level science courses at a local college for a year. When she heard that a science teacher had left a local high school mid-semester, she applied for the job and ended up teaching their biology and chemistry classes for the rest of the year. Though the school was rural, the building was new and her lab was well-equipped. She described it as a "neat experience" and said that she had some "very bright students."

Denise stayed at that school for five years and then took a position in her local school district, where she has taught for the past ten years. According to Denise, she felt

very welcomed when she began teaching there. It is also the same high school that her daughters attended. In her ten years there, she has primarily taught chemistry and ecology courses. Three years ago, she took over the school's Authentic Science Research class, a course where students design and conduct a long-term research study.

Denise finds the school culture to be very positive and feels that most of the teachers genuinely work hard and want to help their students succeed. She thinks that the atmosphere at her school is unique because the faculty is small and they know each other well. It is a well-resourced school where student scores are among the best in the state. In recent years, the faculty has been immersed in developing their professional learning communities and also transitioning to standards-based grading. Denise's professional learning community is her department, which comprises herself and three other chemistry teachers. According to Denise, they get along really well and work together closely. In addition to her professional learning community, Denise's overall experience with her district's PD has been positive. At the school level, she has found most of the PD to be of high quality and helpful to her as a teacher. She also appreciates that her school and district are supportive of teachers pursuing PD outside of the district.

Denise described herself as a "very particular" teacher, who wants her students to do well. According to Denise, "I'm not easy, I'm not hard; I expect a lot. My expectations are high...I want them to do well because I know how important education is for kids today. They can't succeed unless they can succeed in school here." She explained that she is not necessarily concerned with how much chemistry they learn, but rather, she is more worried about them acquiring life-long habits, including studying and organizational skills. As a result, she said that she is "sticky" about little things and very

particular because she knows those skills will be important for her students later in life. For Denise, a really good teaching day is when her students are involved, participating in discussions, and volunteering to come up and do problems on the board. She appreciates when her students recognize that they have done well on an assignment or a test and enjoys watching her students learning the content throughout the school year.

Denise's SciJourn story. As we began her second interview, Denise explained to me how she was introduced to SciJourn when she attended one of the talks given by the research team at a local conference. She was about to begin teaching her school's Authentic Science Research class the following year and thought SciJourn would be a good fit. Students at her school take the Authentic Science Research course as an elective over three consecutive years. The aim of the course is for students to find a topic they are interested in researching, design and implement a long-term experiment, and then write up and present their results. Denise explained that a large part of that process requires that students be able to read and understand scientific literature, so she felt SciJourn would be useful.

***Defining science literacy*.** Prior to SciJourn, Denise knew science literacy was "an issue" and would tell her students that they should be knowledgeable enough to read a newspaper or magazine and to listen to the news and "know if somebody's pulling your leg or not." According to Denise, her students do not understand that knowing science will make them a better consumer. Because she already knew science literacy was an issue, Denise explained that participating in SciJourn did not influence her thinking around science literacy, but rather, she thought it was a "great idea in how to better prepare students for the real world." She also found value in the way the project

presented different ways to engage students in science and different methods to get them to read and write about science in "realistic" ways. According to Denise:

> I just think that's second nature, you know, finding the science in everything. I think I've always done that, but to put a name to it, like they did with the SciJourner, I think is interesting. I just can't imagine teaching that without doing that, but I'm sure there are people who don't do that.

Though she asserted that her understandings around science literacy were not influenced, Denise did find some of SciJourn's teaching strategies useful. She felt that doing the read-aloud/think-alouds helped her students learn how to break down content as they were reading. Pulling up an article on the SmartBoard and talking about it made a "big difference" in teaching her students credibility. She also found value in incorporating more writing into her classes. According to Denise, there were changes in her teaching practices resulting from her SciJourn experience:

> I think I was able to especially think about a little bit harder – not that I didn't do it before – but think a little harder about how I can talk to kids about how science relates to their everyday life and give daily or weekly examples.

She also explained that it was helpful for her sophomore students, who were new to the class, because they did not know how to research. Thus, SciJourn was a good way to introduce scientific reading and writing to those students. As a result, when they were doing research for their long-term projects, they had better knowledge of how to read scientific information and how to discern credibility.

Engagement. Denise's students responded to SciJourn in various ways. Some of her students "felt like it was a waste of their time" because they were more interested in

doing primary scientific research. Consequently, she had difficulties motivating them. She explained that she tried to help her students understand that their long-term goal is to write a scientific research paper and the science journalism model is "just a different way of writing". Her older students, in particular, had difficulties buying into the project because they had specific goals set for themselves centered on their own research and experiments. According to Denise:

> This was probably a little behind what they had already done. So, you know, some, a couple of them, tried, but they had their own goals, which is, like I said, it's an independent learning class, so I couldn't really deny them to do the work that they had already planned.

Denise was surprised, however, by the students who did engage with the project. Some of the students whom she thought would not do well are the ones who did the most, and in her first year, she had six students get published.

Denise explained that her students liked being able to choose their own topics, which aligned with her course goals, where students have to find their own research topic for a long-term experiment. However, choosing topics for the article was more difficult for her students because it had to be current and relevant to an audience. For some of her students, writing for an authentic audience was influential and an incentive for them to invest themselves in the project. Others, however, "could have cared less" because they had other projects they were working on. According to Denise, many of her students felt that SciJourn was adding to their workload for the course. For her sophomores, it was helpful because they learned the basics of doing research and how to find credible

sources, but her older students did not feel that they had time to spend writing in a journalistic style when they had to write a formal, science lab report as their end goal.

Professional development. Denise had mixed feelings regarding SciJourn's PD. She felt that writing her own article during the summer institute was powerful in helping her to understand her students. She explained that she is not a strong writer and has never felt comfortable writing. According to Denise, "Having to actually research and write myself was a big deal. And that, to me, was a real eye opener because I was right back in that student seat learning how to do something that I wasn't comfortable with." She wrote an article on the science behind saltwater swimming pools and went through three revisions before it was published. During that process, she felt that the editor was "quite tough" and his criticisms were sometimes "difficult to take." Denise was the first in her group of teachers to be published, and she was very proud of that, explaining that when she sets her mind on something, she usually does it.

Denise expressed that she liked working with teachers from other school districts, and she appreciated that the research team had diverse backgrounds and were not all "science people". She found it useful to hear what other teachers were doing and to share ideas about lessons and ways to troubleshoot difficulties. She explained that SciJourn was more relevant than most PDs that she has attended because it was matched to her specific interests. However, she felt that some of the PD meetings were "too structured" and there was not enough opportunity to ask specific questions to help her overcome the difficulties that she was having in implementing the project. According to Denise:

> There were a few times when I know I, and then there were other people there too, that had questions that we really wanted answered, and we reiterated that we

> really want to understand how this works. And there were a few times when we were, it felt like literally told, "Well, you need to just be quiet. We have other things that we have planned." It was an interesting situation.

Denise also felt that some schools were favored over others, and those schools received more attention from the SciJourn staff. From her point of view, the PD days had a set agenda and did not account for the fact that the some teachers had a "different clientele" and therefore, had unique needs. Denise explained:

> I almost felt like since I had those better students, that they expected it to be easier for those kids, that I shouldn't be having any issues, that I should be getting better work…where, in all honesty, if you're teaching those kinds of kids, sometimes they're harder to motivate, they're harder to get to change the way they think, and you might have trouble getting them to do things.

When it came to receiving support in her implementation, Denise found it difficult to get someone from the SciJourn team to respond to her and to come to her classroom. According to Denise, "I think that by then, they expected me to be able to do more than I really could." The editor came to Denise's classroom twice and another researcher came twice, which she found helpful, but those visits were not adequate for her to feel sufficiently supported. The editor was effective in telling students when a topic would not work. While some of her students took his advice, others gave up, which Denise felt resulted from the editor not following up with students. She explained, "I wish they would have came more. Maybe I didn't request that enough. I don't know. Not that I couldn't handle it, but I think it helped to have the kids see these people." Denise also expressed frustration over a lack of communication. She would send drafts

to the editor and not get replies regarding the edits that they had made. Or, the editor would respond telling her that her students had not made any changes. According to Denise, "Well, maybe they didn't understand. I'm not sure. And sometimes I just felt like that was the kind of thing that maybe they needed a little more one-on-one. Sometimes, email, you don't read it the same as it's intended." She acknowledged that she felt the editor was being "stretched really thin" and did not have enough help editing articles. Denise, however, found it difficult to impress on her students the importance of a due date when they were not getting timely feedback. As a result, she said that by the end of the second year, she just stopped doing SciJourn in her class because they had other things to accomplish. She explained:

> Honestly, this last year, which was my third year of this course and of students that I had, I just left it. I just felt like, I really felt like it's a great idea, there's some great things in there we can do. I still use things here and there. But, as far as, you know, sending anything to the editor, I was kind of disillusioned about it.

Despite her criticisms of SciJourn's PD and not feeling supported, Denise did find value in the experience. She expressed her appreciation for SciJourn's community of teachers and feels that she could still reach out to any of those teachers if she needed to:

> I think that's more learning to me than anything else is the idea behind having multiple people to be able to learn from…I think the more people you go out and look for and find that are in the same boat that you are that you can talk with, it really does open up ideas that maybe no one else in your building has ever thought about.

She also found the experience beneficial as she learned to teach the research course and was able to focus on teaching students to find credible sources of information. She acknowledged that many of the specific lessons and ideas were helpful, but she often felt she was "just left hanging" and struggled to pull it into her courses like she wanted to. Ultimately, she wanted more support, explaining:

> Maybe it was me. Maybe I didn't ask as often as I probably could have or should have. You know, I mean, I think I always felt like once I walked out of the door, I was on my own. It would have been nice if even someone might have called or emailed and said, "Hey, can we just stop by?" instead of waiting for us to make an appointment.

Denise wished that the SciJourn team would have been more forthcoming with their support. She also felt that her students needed more support and suggested that it would have been nice if each school or district had been assigned one point person who could have worked with them more closely.

***Story to live by*.** There are a few prominent plotlines that emerged in Denise's story. The first was that she is a perfectionist who prides herself on being successful. As she explained, when she sets her mind to something, she does it. She also described herself as "sticky," and she pushes her students to be detailed oriented. She prioritizes her curriculum and is hesitant to break from that structure, which is evidenced by her perception that she did not have enough time in her general chemistry courses to include SciJourn. The second plot that emerged was that Denise did not perceive herself to be a strong writer. Consequently, SciJourn's PD pushed Denise out of her comfort zone when she had to write her own news story. Another plotline in her story was that she teaches in

a high performing district, and the students in her research course are above average. It is Denise's perception that the highest performing students are oftentimes the most difficult to motivate because they do not want to think outside of the box:

> I think a lot of times that they know they're smart and they know they don't have to work that hard to get to what they want. So if it's something that's not really going to be directly beneficial to them, that they don't feel like it's something that they need to do, that they won't. Sometimes those kinds of kids will do the bare minimum to get by, because it's not an effort.

In Denise's case, her story to live by was not altered by her experience with the SciJourn project. While she found aspects of the experience useful and beneficial, the experience did not have a significant influence on her teaching identity. She does, however, give SciJourn credit for giving her more avenues to teach writing than she previously had. Furthermore, based on her experience teaching her Authentic Science Research class, Denise sees herself more as a writing teacher than ever before. She finds that she spends more time teaching students how to research and write in that class, but it is more of an academic style of writing.

Transformative learning. Based on the lack of influence on her identity, Denise did not experience transformative learning through her participation with the project. However, Denise's experience did give evidence to some of the phases of transformation. She applied to participate in SciJourn because she was experiencing a disorienting dilemma. She was given the Authentic Science Research class to teach the following year but did not feel adequately prepared because the course did not have a curriculum, which, based on her story to live by, put Denise outside of her comfort zone.

SciJourn's summer institute introduced Denise to a new way of writing and challenged her as she wrote her own article. She also came away with a series of lessons and strategies that she could use in her classroom. She planned how she would implement the project, and according to Denise, she liked that she could take what she learned and adapt it to her course. For her, that flexibility was important since she was teaching an upper level course that was uniquely based in independent learning.

Implementation. The fall after her summer institute, Denise only implemented SciJourn in her Authentic Science Research course, and due to the nature of the course, she did not require her students to write articles but gave them the option. She did not have a curriculum for the course so she felt that SciJourn gave her something concrete that she could use to get them started. Because the class is a three year course, it was comprised of sophomores, juniors, and seniors. Consequently, while she encouraged her juniors and seniors to participate, she really geared it more towards her sophomore students. She began right away and used the lessons that she had been shown during the summer institute. Some of the lessons she used directly and others she adapted to her course. She began with read-alouds/think-alouds, working her way from reading simple science news articles up to professional science journals. According to Denise, she tried to convey to her students that the articles were on the same subject but were written in different styles and tailored to different audiences. From there, they moved into choosing topics and working through the inverted pyramid. Students were allowed to choose their own topic and then they had to run them past Denise and the editor.

On average, Denise would do about three SciJourn lessons per month, and the students brainstormed and researched in between those lessons. She also required that her

students interview an expert in their field. She gave them a deadline, requiring that they have a completed article to send to the editor to get feedback. She explained that she shared her article with her students so they would understand that criticism and feedback are a critical part of getting to a finished piece. When she received a draft from a student, she would try to edit some of them but struggled. She explained, "Sometimes I didn't really know, especially at the very beginning, I really didn't know how. I mean, I had written my own article with a couple of revisions over the summer, but that was it." Consequently, Denise would usually just submit the drafts directly to the editor and then would read over his edits to get an idea of what he was looking for. According to Denise, she did not feel adequately trained on how to edit. Though editing was a topic of focus in the PD meetings, she felt it was not given enough time and more examples would have been helpful.

During her second year, her implementation was very similar to the first year. That year, her juniors had already written articles the previous year. Some of them chose to participate again and others opted out. During her second year, she tried to review the editor's responses with students but the delays in getting a response caused her students to lose interest. It was during her second year that she gave up the project near the end of second semester.

Denise chose only to implement SciJourn in her research course because she did not have time in her chemistry courses, where she uses lab reports as the primary writing assignments. In the future, she explained that she would like to work with the journalism teacher to create a science corner in their school newspaper where students could submit science articles. She would also like to learn more about infographics.

While Denise experienced some of the phases of transformation, there were particular phases that were clearly missing in her experience. First, though Denise experienced a disorienting dilemma, she never moved into a stage of critical reflection where she began to assess her assumptions around teaching science literacy. Additionally, though she provisionally tried to implement SciJourn in her classes, she never got to the stage where she felt confident in her ability to edit her students' work. Hence, her ongoing need for more support from the SciJourn team. This lack of confidence created a barrier for Denise, and she failed to take ownership over the project and make it her own. Because of this, she never fully integrated the project into her teaching. In the end, she became frustrated by her inability to edit and what she perceived as a lack of support and gave up on the project.

Denise indicated that if she had received more support and more training on how to edit, that she may have been more successful in implementing the project. That said, she ended her interviews by saying that she had shared the book, *Front Page Science*, with her science team because literacy is a "big push" for her school this year. She expressed that she wants her department to collaborate and determine how to incorporate some of SciJourn's ideas into their curriculum. She explained, "I wouldn't do that unless I really thought there were things there that would be helpful."

Jessica - "I like to observe." Jessica is a unique participant to this study. Unlike the other participants, she did not take the survey nor did she attend SciJourn's summer workshop or ongoing PD sessions. Knowing that Jessica had found the project on her own and implemented the project in her classroom without any formal training or support was intriguing to me. I also wanted to compare her experience of learning on her own to

that of the other teachers who were immersed in PD. When I first began developing this project, I had suspected that SciJourn's PD was pivotal. However, Jessica's experience suggested that the PD may not be as essential as I had first imagined, so I wanted to learn more. She and I met for her first two interviews in my office when she was visiting campus in the fall of 2013. For her third interview, we met in her home over a holiday weekend.

Jessica is a white female in her late twenties. At the time of the study, she taught at a suburban middle school in a large Midwestern city. Her school had a population of 921 students, 93% are white, and the other 7% were either African America, Hispanic or Asian. It was a high performing school where 90% of the students met the math proficiency benchmarks on state assessments.

In elementary school, Jessica was primarily interested in anthropology and writing. However, she distinctly remembered learning how different organisms fit different niches, which caught her interest. Later, when she was in high school honors biology and learning about evolution, "the world just opened up," and she started seeing science as the "biggest framework for understanding the world." She also claimed that she "likes to observe" and views science as the primary explanatory lens that she relies on. Today, her love of science is rooted in biology and the applications of it, such as biotechnology, genetics, and evolution; she "loves evolution the most" and finds inheritance fascinating.

Jessica grew up in a suburban school district, attending one of the top public schools in her state. She was a straight "A" student who took honors and AP classes. Her favorite courses were biology and language arts because she enjoyed both science and

writing. After high school, she attended a large, public university where she studied psychology and pre-med and lived in the honors dorm. At one point, she considered dropping pre-med, but she was doing well and enjoyed working with patients so she decided she could see herself pursuing medicine as a career. Her focus was biopsychology and her favorite classes fused the life sciences and psychology: "My favorite thing is evolution and we're going to talk about the psychology of it, like the behavior traits explained? Whoa."

After graduating with her undergraduate degree, she entered medical school at a large, state university. However, she was accepted into the program early and had to accept her spot before knowing which of the campuses she would be placed at. When she learned of her location, she was disappointed. From her point of view, "It's not really healthy for kids to make a choice based on not knowing where they're going to live. It does matter." She was also frustrated that she did not have many female professors and disliked the teaching practices. She went in with the intention of studying neurology and stayed for a year and a quarter, but then changed her mind and left feeling disgruntled towards the medical education system. From there, she returned to work at the Veterans Affairs Medical Center, where she had interned during her college summers. She also enrolled in a transition to teaching program at a local university. It was a nine month program where she was able to student teach during her second semester.

Her interest in teaching stemmed from an experience she had during medical school where she worked at a summer camp with high school students interested in science and medicine. She did not realize how "miserable" she was in medical school at the time, but when she looked back on it, she saw how much she enjoyed seeing kids

getting excited about science. She explained, "So that kind of made me think I could do it. Plus, I like to communicate. And I feel at home with teachers more than medical people because I think they have bigger hearts, which is sad to say."

When Jessica did her student teaching, she worked at the high school level and thought that she would be a "really heavy content teacher" because of her background in medicine. However, she found it difficult to get high school students excited about science because, "they were already over it." When she began her first full-time position teaching eighth grade science, she discovered how much she enjoys working with middle school students, who she views as both expressive and creative:

> I really fell in love with middle school because the kids are really weird and I'm pretty weird. And we like to fly the freak flag. We have fun. They're a lot drama, which I don't enjoy but they're open-minded...and they're a little moldable...And so if you just give them a little bit of love, trust, you have fun, you can get them to be confident in themselves and do great things if you build it.

Jessica taught in the same school for three years, and she described her school district as the best in the county. Her class sizes ranged from 27 to 37 students, and she was one of two eighth grade science teachers. Her school does "teaming" where a group of core content teachers teach a common set of students and they have a "team period" each day where they co-plan and call in individual students who need extra support.

Jessica described a good day of teaching as having a really engaging, structured, and differentiated lesson with a lot of variety, and ideally, some student choice built in without any "meltdowns." She explained how her middle school students are emotional and "kind of a mess," and she has to try to work with that. She told a story of teaching

her students about Maslow's Hierarchy of Needs so that they would try to get enough sleep and eat nutritious foods because that helps to stabilize their emotions.

Jessica described how in her first year as a teacher, she used a lot of direct instruction and projects and gave her students too many choices. She also hated her textbook so she cultivated alternative resources to use in her classes. She collaborated extensively with the language arts teacher on her team and focusing heavily on vocabulary and trying to integrate writing assignments into her science classes. Jessica also said that she was “too fun” during her first year and is working on finding the right balance between having fun with them and setting boundaries for behavior. She describes those tendencies as “teaching immaturity” and explained that she needs to think of her students more as “kids rather than young adults”.

Overall, Jessica’s impression of PD in her district was that it did not meet her needs. She described what she called “dine and dish” lunches where the instructional coach in her building gave out packets of information during their lunch break. According to Jessica, “I’m not so good at paying attention during lunch and, shoveling food.” Consequently, she just collected those packets in a binder and didn't use them. She also told the story of her district offering a seminar on the Common Core in the content areas, and she was only one of two teachers who showed up. During the summer, she also attended a district PD where they were asked to annotate the standards, which she described as “demeaning" because she had been immersed in learning about the Common Core standards for three years. Her overall perception was that the district did not have high expectations of the teachers and there was an overall “lack of rigor.”

To overcome that culture, Jessica asked to lead a PD where she showed teachers how to quantify and triangulate data. She described the experience by saying, "I did put on that professional development, and let me just say it was really differentiated and the survey said we did well. I don't think it transformed anybody, but it was available." She also perceived a level of complacency in her district, which she attributes to the fact that her district performs well. She also thinks that her district spreads their teachers too thin, expecting all of them to coach or participate in extracurricular activities. According to Jessica, "The teacher should be teaching first and foremost. And I will do those things, but that just means I will take time out of something else for my class, because I will not take the time away from my class. So it means I take it out of my personal life."

Jessica's SciJourn story. Jessica's involvement with SciJourn is unique in that she found the project through the National Science Teachers Association (NSTA). She recalled reading NSTA's publication *The Science Teacher* and the book on the SciJourn project, *Front page science: Engaging teens in science literacy,* was listed under "recommended reads." She read the excerpt describing the project and thought it sounded interesting, so she ordered the book.

***Defining science literacy*.** She attended a couple of PD days over the summer after her first year of teaching. She described the days, as "completely unstructured" so she utilized the time by reading and annotating *Front Page Science*. She went back and took detailed notes on the book later that summer but then left it at the start of her second year of teaching. The book resonated with Jessica on multiple levels. At the beginning of the text, the authors discuss the flaws with approaching science education as "training little scientists," which aligned with Jessica's viewpoint. She was also struck by the

project's definition of science literacy, which she described as "an offshoot of information literacy." According to Jessica, SciJourn's definition of science literacy encompasses everything she would "ever dream of teaching" her students including: how to use information, how to understand it, how to understand the world, and how to write. She explained:

> I don't care if my kids become scientists…I want them to be inspired to do whatever they want to do. And understand medical information and understand information. Understand the Internet or how credible something is. That's huge. So I was like, "yes, that's what I agree with. Okay, reading on." I'd never heard it like that.

That framing of science literacy aligned directly with Jessica's teaching goals. She articulated, "When I read that, I was like this is exactly what I think, and I'm really glad that somebody else has already researched it and written a book about it because I've been waiting for this project." She had been searching for an engaging research project but "did not know what it would look like". When she found SciJourn, she saw that it would hit the Common Core standards and teach her students skills they would need for life, while also engaging them.

Teaching her students how to find credible sources of information was pivotal for Jessica. She described how her students "don't realize that a computer is more than a big phone." As such, they do not look up topics and do not understand that they have the power to understand their world. She explained that oftentimes, her students do research for the first time in her class. She thought that her students would know "way more" about navigating the Internet because they have had access to it throughout their lives.

From her point of view, while her students are the "technological generation," they are not accustomed to using technology to find information. Instead, her students primarily use technology for social media, to play games, and to watch Youtube. She explained, "They really think it's a big phone. They've said that to me." In response, she said that she is "like a broken record" constantly telling her students to look up information and reminding them that they have computers to use.

Engagement and authenticity. While she has always aimed for engaging lessons, the SciJourn project took her students' engagement to a new level. She explained, "this project gets them. If they put something into it, they get that thing out of it times ten." She accredits much of that engagement to students choosing their own topics which leads to ownership. She explained that in middle school, her students do not have many longitudinal projects that incorporate student choice. She also noted that they do not have elective courses so they are not accustomed to getting to make academic choices based on their interests.

Consequently, she considered the "personal piece" of the project as being critical: "You're writing about something you know. The research is there, but I'm a kid. Let me write about myself a little bit. Let me write to understand myself. You know, kids should have that right." She explained that letting them have freedom to choose their own topics was "scary but good" and also cathartic for her students. She told the story of a student who had gone to New York to visit an aunt who was dying of cancer. Upon her return, the student chose to write her article on her aunt. As she was researching in the classroom, she began to cry and when the other students noticed, they started making funny faces at her, which made her laugh and cry simultaneously. According to Jessica:

> She was researching something intellectual and she was able to have an emotional release. But she's in a safe place in my room…Because we had that project she had a chance to look it up. So SciJourn. Without SciJourn she wouldn't have looked it up. So I think she'll be more ready with whatever happens with her aunt. She has grieved a little bit or let it out. Kids don't usually cry in my class.

She also explained that it "blows reading level out of the water" as she saw her students navigating complex text because they were interested in the topic and really wanted to understand it.

Jessica felt that her students' engagement was closely tied to the authenticity of the project because SciJourn gave her students a real audience and the opportunity to be published on the web as well as in print. That was very unique for Jessica's middle school students, who were excited that they were the only students in their district writing articles. The students also were motivated when they got emails back from experts. For Jessica, it was the combination of that real audience and the personal piece that resulted in what she called, "authentic engagement, learning for the sake of learning." She described that by saying:

> I sort of knew that as soon as I really unleashed the project something magical might happen. And I was just like, whoa. The class is completely silent and they were authentically engaged. It didn't look like authentic engagement always looks, but it was. It's the first time I ever hit authentic engagement. You can do simulations, but this is very real because of the authentic audience.

Professional development. When Jessica began the project, she felt that she was working in isolation. She had a colleague, a language arts teacher, look at her graphic

organizers and rubrics to help her refine them, but otherwise, worked alone. After she had a student published her first hear, she found the website teach4scijourn.org, where she uploaded several of her lessons, which opened up the dialogue between her and the editor. The editor invited her to a PD that was being held for teachers in Kentucky, and she travelled to participate in the workshop. She brought along her binder of resources, which she shared. She explained that it was very helpful to hear what other teachers were doing, which is what got her excited about having her students pitch topics during her second year. She met again with those same teachers during the summer to plan a larger conference for the fall. Jessica described her appreciation for finding that community of "likeminded people." She explained that she had begged people in her district, trying to get them interested in the project with no response. She even shared the project with a representative from her state's Department of Education but was met with little interest. This resulted in her feeling, "ashamed of my own state."

A new story to live by. Prior to SciJourn, Jessica's story to live by had three prominent plotlines. The first was that she was a new science teacher, without a lot of experience. She referred to herself as a "baby teacher" and spoke more than once of her need to develop some "teaching maturity." The second plotline was that she is a "careful and deliberate lesson planner" who thrives on structure. The third was that she wanted to think outside of the box and be innovative in her teaching. These joint stories caused some conflict for Jessica. While she realized that she was inexperienced, she also believed that she had the academic skills and tenacity to be an excellent teacher and prided herself on working hard. Though she works in a high performing school, she was also dissatisfied with the complacency that she witnessed and believed that expectations

of students should be increased. While she tried to take initiative in her school and district, she was not always well-recieved explaining that she can be "intimidating" and is viewed as a "rogue" teacher because she brings innovation to her classroom. Others view her as unrelatable and having more time to dedicate to teaching because she is young and single.

Jessica's story to live by was further evidenced by the initiative that she took in her school district. She explained that she disliked her district's science textbook so she sought out other resources. She did not like the school's existing curricular materials, so she unpacked the standards herself. She described how her course materials have "become the pacing guide and the scope and sequence for the eighth grade curriculum in the district." In implementing SciJourn, Jessica explained that she had to use her imagination and felt like she was taking a risk because she spent four and half weeks on the project. She was able to carve out the time time, however, by condensing her curriculum and did so because she felt it was "best for kids."

Jessica described her teaching mission statement as "creavitiy, content, and confidence" and emphasized wanting her students to believe in themselves both personally and academically. She explained that while she is a deliberate lesson planner, she is also respectful of "divergent paths and divergent thinking." Consequently, if her students are engaged in a project and it takes two days longer than expected, she is "okay with that because it means they are learning." According to Jessica, she has a "patience problem" and struggles not to get bored while teaching the same class five times in a row. She also struggles with classroom management while maintaining rigor:

> I'm still a pretty new teacher. I fight myself a little bit on the fun. Because I have really high academic expectations. Kids have said on their exit evaluations that I test really hard so watch out, but I'm also trying to have fun during class. So that may send a mixed message.

She explained that she hates to discipline students and she is not "very good at it," although she knows it is necessary.

Her interest in literacy and writing stems from her own experience as a student. While in college, she saw that most of her peers did not do the assigned readings for class. She described herself as the student who read the chapter before the lecture and then re-read it again afterwards. Until college she had thought of herself as having an average writing ability. While in college, however, she realized that many of her peers struggled to write papers. She began to see herself as one of the few people who were "really proficient" at writing and it was troublesome for her. As a result, she perceives writing as an essential communication skill and aims to give her students a valid opportunity to develop their writing abilities. She credits her confidence in her own writing to helping her implement the project because she trusted that she could accurately model the necessary skills. From her point of view, science teachers fight teaching writing because they are intimidated by it.

Prior to finding SciJourn, Jessica explained that she perceived science literacy as any time the kids were reading or writing science, and she focused heavily on literacy strategies. According to Jessica:

> I was appealing to multiple intelligences or whatever when you're doing writing in science, but I think I couldn't really sign off and say, okay, they're read to go to high school and whatever kind of reading comes their way, they'd be ready for it.

After reading *Front Page Science*, however, her understandings around science literacy changed. She explained, "When I was reading I realized that was what my definitinon was of science litearcy: for kids to understand science as information consumers, like information literacy...so a more contextualized view rather than just in my science class." She also realized that she needed to move beyond having students read particular texts to teaching them to find appropriate texts. This took some pressure off of her. Since she disliked her textbook, she explained that she was always concerned about having reading materials. After doing SciJourn, she now lets her students find some of their own readings.

Because of SciJourn, Jessica explained that she was no longer afraid of having her students read complex text and also became "less afraid of doing a full scale research project." In the beginning, she was unsure of setting aside large segments of time in her science class to dedicate to research and writing, but her experience with SciJourn made her prioritize it. She also acknowledged that it may take time for particular skills to set in, and they may "show up second semester or when I'm not around." However, from her point of view, "the project only can benefit kids." Even after she was done implementing SciJourn, her students kept connecting back to various aspects of the project whether it was in using search terms or attributions. In Jessica's words, "The SciJourn beat kept on."

According to Jessica, she will continue to use SciJourn for as long as she teaches. She believes the skills transcend the media that is available, so even as technology evolves, SciJourn will still be applicable. She explained, "So they're always going to need to know how to find informaiton and communicate it. The skills are very general. This is a very general project that can go in any classroom. So you could really adapt it." Even without the print or online newspaper, Jessica maintained that she would try to be innovative and devise new ways of making the project authentic. She described her idea of having a poster night in the community, where students would have poster sessions and would present their work to parents and other stakeholders. She would also like to explore other news outlets and ultimately, would like to take the project "to a bigger stage of community involvement."

Using SciJourn altered Jessica's story to live by giving her a sense of validation as a new teacher. The project reinforced for Jessica that taking risks was necessary in order to push her students towards high expectations. It also validated for her that being innovative, though challenging, can also have big payoffs in the classroom. The project gave Jessica a set of tools that allowed her to integrate research and writing into her classes in a deliberate and rigorous way. As a result, she no longer identified as an inexperienced teacher, but instead, she began to see herself as having some expertise. This change in her story to live by was further reinforced when she joined the SciJourn community and other teachers wanted to use her materials. In joining that community, Jessica felt, for the first time, that other teachers were interested in her approach and valued her knowledge.

***Transformation*.** Jessica's changing story to live by gives evidence to transformative learning**.** Her transformation began when she experienced a disorienting dilemma her first year of teaching. She was integrating writing into her classes and was trying to hit the Common Core standards, but she explained:

> I really didn't feel like I could sign off on myself, for my own personal accountability that I was giving the kids the skills they needed. I knew I was preparing them for high school, but I wasn't preparing them for the world. So I was looking for it, yes.

It was that need to sign off on herself that led Jessica to SciJourn. When she first found the book, *Front Page Science,* she thought it might help her integrate more reading and writing into her classes. She did not expect for the project to transform her classroom in the way that it did. She was hooked by the project's definition of science literacy, which she adopted as her own. Aligning her teaching with SciJourn's principles required that Jessica take a risk and also re-negotiate her curriculum. According to Jessica, "I knew I was going to do it, but not when was I going to do it. And then I finally decided to bite the bullet and get into it." She was nervous about doing the project so as a lead into it, she started doing read-aloud/think-alouds during the first nine weeks of school.

Implementation. She officially started the project the week before fall break and then her students worked on SciJourn every Friday for the rest of the semester. She began by adapting SciJourn's Student Article Filtering Instrument (SAFI) into a rubric where she broke the items down and made them accessible to her students. From there, she had her students do some textual analysis of news articles using the rubric and color codes. She then gave her students graphic organizers for their research that helped them

find credible sources. She created a series of mini-lessons that were designed around the tenets presented in *Front Page Science.* During her first year, she had all of her students go to EurekaAlert!.org, a website that publishes press releases, to find current topics that interested them. She used EurekaAlert!.org because it guaranteed that her students found newsworthy topics. To probe them on their topics, she asked questions straight out of *Front Page Science,* such as "why are you interested in that?" or "what makes you interested in this topic?" Once they found their topic, she had her students start researching and creating a framework around their news story. At that stage, they focused heavily on using search terms and assessing credibility. She explained:

> It makes teachers more comfortable if they can give the kids a set of resources or set of rules, but the students have to find multiple sources and they're not going to just go with what I say. They're going to find them themselves.

Jessica closely followed the book's suggestions explaining, "Once I read the rationale, the beginning, I read most of the research part, I was like 'okay, I'll do what they say'." She used many of the online resources but adapted them and made them her own. She "workshopped" her students through the different elements of the article using the rubric that she had created. She also taught her students how to identify experts and stakeholders and how to communicate with them. She required that her students either conduct an interview with an expert or use a survey. At that stage, many of her students contacted press officers at EurekaAlert! or scientists who specialized in their field and "freaked out" when they got responses back. Jessica also described how her students "loved" to do surveys using Google Forms and particularly enjoyed surveying their peers.

Her students did not have to write an article, but instead, had to submit a final "product." She explained, "The product I told them could be anything. As long as it meets these rubric expectations, which is what the books says to do, it can be any product." Though they were given the choice, all of her students chose to write articles. After doing their research, her students wrote their first drafts. She then developed two different graphic organizers for peer review and focused more on editing than the book suggested. One of her peer feedback organizers was a "light" one and the other was a "heavy technical" one. Jessica explained that the technical rubric, which was not part of her rubric, was designed for her colleague who was a language arts teacher, because she would appreciate having the students do it. From there, the students revised and re-revised their work until they got to a polished piece. A few students submitted for publication, and one was accepted. She had hoped that more students would get published but many lost momentum over their winter break.

Jessica found that SciJourn was a "nice relief from heavy content," and her students had fun with it. She explained that she made her students press passes and "branded the thing like crazy." She featured SciJourn in their school newsletter, and she Tweeted about it. She described trying to "make it cool" and playing it up as an exclusive project that none of the other students were doing.

Her second year of implementation was "much more open." She learned from her first year that she needed to complete the project in one semester because students lost interest over a long break. That year she started during the first week of school using what she called the "journalism jumpstart" where she "pre-assessed" her students and gathered baseline data. She asked them to identify which search engines they use and

what search terms they would enter. They also read an article and had to paraphrase it. According to Jessica, "It teased them with the idea of the project from the first day. And from the first day of school my kids were really good because they were writing and researching." After doing the jumpstart, she left the project to work on another unit and then came back to it, but she found that her students were motivated because she had set the tone early on. Instead of using EurekaAlert!.org, she let her students search for topics. In doing so, she had to be very specific in teaching her students how to enter search terms.

Once they found potential topics, she had them start pitching. Because they had not used EurekaAlert!.org, many of their topics were too broad and she had to work with them to focus their topics. At the time of the interview, Jessica's students were starting to write and some were telling her that they were ready to submit a final draft. She also had some students who were interested in creating movies rather than news articles. During her second year, she was having her students submit their drafts to her at various times so she was not "stuck grading all of them at once".

As she discussed her challenges, Jessica explained that it was very difficult to teach her students not to plagiarize and also how to attribute a source rather than cite it. She found that she spent several lessons covering those topics, and it was often difficult to come up with multiple lessons teaching the same concept. She also found it difficult to juggle having students at various stages of the project. To cope with that, she had some of her students work as peer assessors when they were further along. The grading was another struggle. Her first year she did not pace the students submitting articles and found she was overwhelmed with so many to read at one time.

Jessica explained that it was easy to make time for the project and she felt "it actually took some pressure off of me for content." She used the project to fill in holes in her instructional time, eliminating some of the "fluff" in her class. She considered the end of the week, when she did not want to start something new, as the perfect time to throw in a mini-lesson on SciJourn:

> It created this something. I always had something to plug in for flexibility. And I would come up, I would do a mini lesson or I would have different stations for the kids for what they needed. And it was also kind of a catch up day. While kids were working I could do other stuff. It was a good work day. It helped me with the planning. I didn't have to force something with chemistry like watch a dumb video that we didn't want to watch.

She also explained that modeling was integral to the project, which is a strategy that she relied on. Her school implemented what they call “choice reading time” during the first 25 minutes of the day. During that time, her students were asked to journal about what they were reading and discuss it with their peers. Jessica explained that she disliked that designated reading time because the focus was typically on young adult books. After doing SciJourn, however, she began using that time to intentionally model her own literacy focusing on what she described as the “non-fiction text connection.” She explained how she would tell the students about stories that she heard on NPR and would model how she made connections to other texts and also to her life.

Jessica’s transformative learning experience gave evidence to all of the phases of transformation. Her transformation was epochal, being triggered as she read the first chapter of *Front Page Science.* In her case, transformative learning was then reinforced

as she took the risk and successfully implemented the project on her own. For Jessica, the phase of building confidence and self-confidence in new roles and relationships was also pivotal. In particular, her experiences with the teachers in Kentucky gave Jessica a sense of "validation" that her interpretation of the *Front Page Science* was accurate, and she felt valued when other teachers were using her materials. She described that experience by saying:

> I just feel like I'm in a minority of people who see science literacy the way I do. And so I'm like, okay well, this is an NSF grant. This has been presented at NSTA. This is a professional development that is rolling out in Kentucky. There's something here and it's not just me. So there was this sense of community too. And it's given me some other opportunities too like when I got to present at the conference.

This sense of validation was influential for Jessica as a new teacher who was trying to develop confidence in her teaching abilities. Jessica summed up her perception of the project by saying, "It's the hottest science literacy project out there."

Chapter 6: Cross-case Analysis

The five cases just presented give evidence to each teacher's unique experience and individual SciJourn story. Each of these teachers brought to the project their own specialized needs, their varying teaching contexts, as well as their differing backgrounds and experiences. Having presented the particulars of each case, the next phase of my research required that I look across these teachers' stories and experiences as I sought to uncover a series of cross-case conclusions. In this cross-case analysis, I continued to seek answers to the research questions presented in chapter five: How did participation in the SciJourn project influence science teachers' professional identities, knowledge, and classroom practices? In what ways were teachers transformed?

Through their participation in the project, four of the five teachers experienced transformative learning, which, consequently, resulted in a shift in their stories to live by. One teacher, Denise, was not transformed and did not experience an identity shift. While there were several commonalities in the experiences of those who were transformed, I found three prominent themes that emerged across their stories. The first and most significant theme was the influence of SciJourn's definition of science literacy. The second common theme was student engagement and authenticity, while the third common theme was the influence of SciJourn's PD. The following sections will explore these commonalities in more detail.

Reconceptualizing Science Literacy

For all four of the teachers who experienced transformation, SciJourn's vision of science literacy, as preparing students to navigate science-related issues 15 years out, played a decisive role in altering their thinking and also their teaching practices.

Ultimately, this definition was the catalyst for each of these teachers to begin critically reflecting on their assumptions around science literacy and thus, set the stage for transformative learning to occur. Unlike the other teachers, Denise, who did not experience transformation, explained that she was not influenced by SciJourn's conceptualization of science literacy. Furthermore, she did not come to the project because she was interested in science literacy but rather, because she had to teach a new course that centered on research writing, and she thought SciJourn would give her something to do to get her class started at the beginning of the year.

Conceptual change theory. While transformative learning theory was the predominant conceptual lens used in this research, I found it useful to draw on elements of conceptual change theory, particularly as I explored how teacher's conceptions of science literacy were influenced. Conceptual change theory has long been used in science education to shed light on how students learn science and also as a framework for designing learning experiences within science classrooms. Less commonly, conceptual change theory has been applied to teacher education. Yet, it has proven to be a useful framework for understanding how teachers change their ideas about teaching and learning (Larkin, 2012). According to Strike and Posner (1992), conceptual change theory is concerned with how learners make the transition from one conception to a successor conception. However, not all learning results in a conceptual change. The theory is specifically concerned with concepts that are foundational or those that play an organizational role in thought and learning. Thus, Strike and Posner (1992) align conceptual change with Kuhn's notion of a paradigm shift.

In order for conceptual change to occur, certain conditions must be present. First, an individual must be dissatisfied with a current conception, one that has somehow become dysfunctional or less useful. Second, the new conception must be intelligible, and the learner must be able to make some sense of the new idea. Third, the new conception must seem plausible as a new form of truth. Finally, a new conception must seem productive as a new way of thinking, one that opens up new possibilities of inquiry (Strike & Posner, 1992).

Another important component of conceptual change theory is the notion of conceptual ecology, otherwise known as a learner's conceptual context. According to Strike and Posner (1992), this conceptual ecology "consists of such cognitive artifacts as anomalies, analogies, metaphors, epistemological beliefs, metaphysical beliefs, knowledge from other areas of inquiry, and knowledge of competing conceptions" (p. 150). In their later work, Strike and Posner (1992) revised the notion of conceptual ecology to also include an individual's motives, goals, and institutional and social influences. From this point of view, one's conceptions are historically conditioned and ultimately, inclusive of prior knowledge. Thus, new concepts are understood and evaluated based on the concepts that a learner already retains.

A changing conception of science literacy. As mentioned previously, SciJourn's definition of science literacy was particularly influential for the four teachers who experienced transformative learning. As I explored the change that occurred in these teachers' ways of thinking, it was important to consider their conceptual ecology around science literacy. Each of the four teachers brought with them a set of assumptions around science literacy and what it meant for their students. Both Brian and Johnny were

explicit in their understanding of science literacy as being able to read the textbook, while also navigating chemistry content. These two teachers were primarily concerned with teaching their students to decipher vocabulary as well as the fundamental concepts dictated by their curriculum. Charlotte and Jessica's conceptions of science literacy were centered on teaching students not only to read science but also to write science. Charlotte explained that she thought of science literacy as having her students study vocabulary and also having them write lab reports, while Jessica assumed that science literacy was based in all of her reading and writing assignments.

These teachers' conceptions of science literacy are not surprising. In fact, they align directly with traditional notions of what it means to be scientific literate, falling into that first science literacy "camp" that Newman described. It is important to consider that these traditional perceptions of science literacy have been socioculturally constructed within the science education community. These kinds of sociocultural perceptions represent the taken-for-granted belief systems that are legitimized by institutions. Regarding science, one of the prevailing perceptions is that science is for an exclusive few. In her interview, Saul likened the science curriculum to the hazing that occurs in a fraternity: if an individual can master the science content, then he or she becomes a member of the science club.

Bybee (1997) suggests that science literacy metaphorically represents the goals and purposes of science education. If we look to science curriculums and textbooks as representative of these goals and purposes, it is clear that the emphasis continues to be on traditional, scientific content. While the Next Generation Science Standards (NGSS) have begun to challenge this traditional focus, the implementation of those standards is

only in the very early stages. It should be no surprise, then, that the participating teachers brought with them views of science literacy that prioritized content as well as textbook-based literacy. Of importance, however, is that while they subscribed to the traditional conceptions of science literacy, these conceptions also had consequences for the ways science literacy was taught, which proved problematic for these teachers. This was demonstrated as each of the teachers described how they came to the project struggling to successfully integrate science literacy into their classrooms. For all four of them, this struggle led to a disorienting dilemma and thus, a search for new teaching practices. Each of their dilemmas, however, were unique to their individual experiences. Charlotte's disorienting dilemma resulted from not feeling adequately equipped to assess her students' science writing. Brian was searching for a rigorous way to embed science literacy in his chemistry classes, while Johnny's disorienting dilemma came when he realized that his definition of science literacy, which emphasized reading and decoding science text, was flawed. Jessica, on the other hand, was searching for an authentic project that would include all of the skills that she felt were necessary to adequately prepare her students to read and write science. Each of these teachers, then, met the first condition required for conceptual change to occur, where individuals must become dissatisfied by their current conceptions. Because of their challenges around teaching science literacy, these four teachers came to the project with the disposition that they were open to exploring new ideas. They each had a question and needed the project in their own, individualized ways.

As Newman explained, SciJourn's definition of science literacy became the project's "elevator speech". In other words, the definition became the project's

conception statement. According to Larkin (2012), a conception statement is a phrase or single sentence that conveys a “précis or theme statement” of the idea (p. 27). As such, when presented with SciJourn’s conception statement, the teachers began to interrogate their current assumptions around science literacy. The concept of preparing their students 15 years beyond high school graduation made sense to them on a deep level. Charlotte explained that prior to SciJourn, she "didn't understand" the skills that her students might need 15 to 20 years from now. Likewise, Johnny said that before SciJourn he had "never considered" teaching his students to evaluate the credibility of sources. Brian suggested that he now considers preparing his students to navigate science-related issues 15 years out as "the most valuable skill students can have." Similarly, Jessica explained that she now sees that her students need to be able to understand science as "information consumers." For each of these teachers, the definition resonated with them in a particular way and influenced them to reconfigure their teaching priorities. In this way, SciJourn's articulation of science literacy met the second criteria for conceptual change by being intelligible to the teachers.

Of importance, SciJourn’s conception of science literacy was not just theoretical but was also embedded within a PD that gave the teachers a toolkit of strategies for implementation, as well as a community of support. As a result, this new conception of science literacy met the third criteria for conceptual change because it seemed plausible for the teachers. Within their community, they were able to share strategies for implementation and witnessed other teachers having success with the project, which reinforced that the project was more than just a good idea; it was also actionable. Not only did SciJourn's definition give teachers direction in terms of how to think and teach

science literacy, but it also opened up a new spectrum of possibility. Teachers were given the freedom to innovate within the project and also to adapt it and make it their own, which led to significant changes in the ways they embedded reading and writing in their teaching. In this way, SciJourn's definition met the fourth criteria for conceptual change as it proved to be a productive new way of thinking that allowed for both innovation and inquiry.

In conceptual change theory, a conceptual change is considered to take place when an idea changes or is replaced by a new one. As seen here, SciJourn's framing of science literacy was the central, theoretical mechanism that influenced these four teachers, to begin to change their thinking. The resulting conceptual change, in turn, became the catalyst for the teachers to begin to engage in critical reflection, an initial step in the process of transformative learning.

Critical reflection. An individual engages in critical reflection when he or she thinks back on and analyzes the presuppositions of prior learning. According to Mezirow (1990), "We become critically reflective by challenging the established definition of a problem being addressed, perhaps by finding a new metaphor that reorients problem-solving efforts in a more effective way" (p.12). Becoming aware of assumptions, however, can be extremely difficult, particularly when those assumptions are tied up in sociocultural understandings. According to Brookfield (1990), becoming aware of assumptions that have been internalized to the point that they are second nature is problematic simply because of the familiarity of the ideas. Doing so can be psychologically threatening as it can disrupt the very foundation of what we know and

believe to be true. In the words of Brookfield (1990), "the whole structure of our assumptive world crumbles."

In the case of SciJourn, the conceptual change that was triggered by the project's definition disrupted the teachers' habitual expectations of what science literacy means and how it should be taught. As a result, the validity of their meaning perspectives, which were predicated on traditional assumptions of science literacy, was then challenged. Furthermore, the teachers became critically aware that their assumptions were constraining their options for integrating science literacy instruction in their classrooms. Thus, it was this conceptual change that made critical reflection possible and set the stage for the phases of transformative learning to occur. Ultimately, the teachers first came to the project to explore new ways of teaching science literacy. What occurred, however, was a paradigm shift. The SciJourn experience, then, was not just about learning new approaches to teaching science literacy but rather, learning new ways to think about science literacy. Therefore, the conceptual influence of the project resulted in a powerful learning experience for the teachers.

Engagement and Authenticity

The second common theme that emerged across these four cases was student engagement. All four of the teachers acknowledged that their students' engagement with the project was a driving force for them to continue implementing and working through their various struggles. In other words, their students' positive feedback sustained them as they worked to fit the project to their own context. Charlotte explained that student engagement was just "as important as the science literacy part." For Brian, seeing his students thinking "about a project outside of class time" was striking. Johnny considered

his students' engagement one of the "successes" of the project as he witnessed his students talking "about something scientific." Jessica described seeing "authentic engagement" for the first time in her classroom as a result of the project. For Charlotte and Jessica, their students' engagement was as equally influential as SciJourn's definition of science literacy. Each of them described their implementation of SciJourn as a powerful force that changed their classrooms. Charlotte described this force as an "essence" while Jessica referred to it as "something magical."

Charlotte, Brian, and Jessica also explained that the project's authenticity was vital, as it gave their students a real audience. According to Charlotte, the real audience of the newspaper was a "big deal" for her students, while Brian saw value in having his students write something "that other people will read." For Jessica, the authenticity proved significant when her students received email replies "from experts." For these three teachers, engagement and authenticity were closely linked as they attributed the authenticity to increasing student engagement; thus, the real audience was motivational for their students.

Professional Development

Another common theme amongst these teachers' stories was the importance of SciJourn's PD. In order for transformative learning to occur, learners must have the intention and the skills to act on their new conceptions, and in SciJourn's case, the PD facilitated teacher action by fostering a learning community that was conducive to transformative learning.

SciJourn as a community of practice. SciJourn's PD was intentionally designed to create a learning community where teachers could come together to engage in a

dialogue about ways to enrich their methods for teaching science literacy. The PD was not focused on how teachers teach but rather how teachers learn. It was not about creating lesson plans or giving formulaic guidelines for implementation. Instead, SciJourn focused on teaching the teachers about science journalism as a genre, while also asking them to think about science literacy in a new kind of way.

If we look to Wenger's (1998) three design components, engagement in meaningful learning, imagination, and educational alignment, we can see how SciJourn evolved as a community of practice. First and foremost, SciJourn's social practices engaged teachers and positioned them at the center, which points to Wenger's first condition for fostering a learning community. The teachers were invited into the community and given opportunities for engagement and investment. From the very beginning of the institute, the teachers were made to feel welcomed and valued. Each morning, breakfast and hot coffee were available. The room was set-up in a semi-circle and the researchers integrated themselves with the teachers. At the start of the day, a member of the group would read aloud notes that he or she had taken regarding the previous day's activities. This would generate a dialogue about what the teachers were learning and provided the opportunity for teachers to ask questions.

Throughout the project teachers were engaged in meaningful learning. Unlike much of the PD available, SciJourn did not focus solely on strategies or giving teachers a pre-packaged approach to implementing science journalism. Instead, SciJourn invited teachers to begin thinking differently about science literacy and then engaged them in a series of learning activities that reinforced their new conceptions. Much like the NWP, writing was an integral part of SciJourn's PD. Because the project focused on science

journalism, it was imperative that teachers become familiar with science news, so they were tasked with writing their own news articles. The teachers had to pitch topics, conduct research, formulate their ideas, and submit drafts of their articles to the editor for review. The editor gave the teachers feedback and asked that they make specific revisions. Many of the teachers, particularly those who did not see themselves as strong writers, struggled with this process. Though they could have simply handed the teachers an outline of an article and a series of lessons designed to teach it, the researchers wanted the teachers to experience the actual writing process. By engaging with the process on a deeper level, the teachers were able to internalize the journalistic style of writing. In addition to writing articles, at the end of each session, teachers were asked to blog about their thoughts on that day's activities. In this way, writing was used as a tool to help the participants process their new knowledge and also to reflect on what they were learning. As science teachers, most of the participants did not see themselves as writing teachers. However, by making writing a foundational piece of its PD, SciJourn influenced many of the teachers to begin thinking about using writing in a different kind of way. In this way, the project met the third criteria for fostering a learning community, educational alignment. By pushing the boundaries of reading and writing in science, the project opened up new possibilities for science literacy instruction.

Throughout the project, the teachers had a voice and were given the authority to problematize alongside the researchers. In this way, the teachers were an integral part of the design process. They worked alongside the researchers to create lessons that could be used. They tried various approaches to implementation and shared what worked and what did not work. The flexibility of the project gave the teachers the freedom to

approach it in personalized way. Not surprisingly, implementation looked different in every classroom. At the PD sessions during the school year, the teachers would often talk about their successes and struggles with the project. These sessions gave the teachers an opportunity to come together as a community and share their knowledge. As the project progressed, the teachers who had been involved since the beginning became mentors to the new teachers as they shared critical insights into what they had learned along the way. These sessions inspired teachers to try new approaches or to even try again if their approach did not work the first time around. This illustrates Wenger's (1998) second criteria for fostering learning communities, where learners are encouraged to use their imaginations as a means to expanding the community's knowledge.

The teachers were also involved in SciJourn's research, where teachers, their classrooms, their students, and classroom artifacts provided rich sources of data to inform the project. Several teachers and students were interviewed about their experiences. There were numerous classroom observations. Teachers were also involved in focus groups and invited to give feedback on research and publications. These conversations not only gave the teachers a voice but also reinforced their sense of agency. The teachers also shared their ideas for research topics, were invited to be co-researchers, and were encouraged to use their classrooms as sites of inquiry.

For Charlotte, Brian, and Johnny, SciJourn's PD was particularly influential, and they each discussed the importance of writing their own news stories as part of their training. Charlotte explained that she valued the positive atmosphere of the PD sessions and felt like she was "coming home." According to Brian, the follow-up sessions helped him stay accountable and "remotivated" him. Johnny admitted that the meetings made

him feel better; he realized the "pitfalls" he was experiencing were not unusual and came away from the meetings feeling inspired to keep trying. The PD sessions introduced these teachers to SciJourn's principles and also gave them a set of tools and strategies to implement the project in their classes. Each of these teachers also felt a sense of community and support from the PD, which was influential in motivating them and helping them to overcome their struggles with implementation. For Johnny, the influence of that community was equally as important as SciJourn's definition of science literacy because it gave him the ambition to keep trying despite his continuous struggles. For both Charlotte and Johnny, the flexibility of the project was also significant as they appreciated having the freedom to change and adapt the project to their own teaching contexts. Charlotte found that it was useful to have her middle school students write articles in pairs, while Johnny eventually settled on having his chemistry students create infographics. While SciJourn's definition of science literacy proved to be the driving force behind these teachers' transformations, the PD sessions were the vehicle for the transformations to occur because it equipped them with the skills and support that were necessary for success.

Jessica's experience with the PD was unique because she did not attend PD sessions until after she had already implemented the project in her classroom. For her, the book, *Front Page Science,* was the primary vehicle for her transformation. Reading the book introduced her to SciJourn's definition of science literacy, which resonated with her on a deep level and hooked her into wanting to pursue the project more thoroughly. The book also gave her the tools that she needed to implement the project, although it was her own willingness to take a risk that led her to action. Later, when she connected

with the SciJourn community, she felt a sense of "validation" in her implementation of the project. This community offered her support and also provided a forum where she could share her ideas. In Jessica's case, her transformation began when she read the book and was introduced to SciJourn's definition but was reinforced when she found the SciJourn community and was able to connect with a group of "like-minded" people.

Transformation Across Cases

Phases of transformation. The three common themes presented here were essential to these four teachers' transformations. While SciJourn's conceptualization of science literacy proved to be the trigger that set the process of transformation in motion, students' engagement and the professional development sessions were also salient and significant. If we look to Mezirow's ten phases of transformation, each of these four teachers experienced all ten phases of transformation, with the exception of Brian who did not show evidence of stage two: self-examination with feelings of fear, anger, guilt or shame. While the other teachers did give evidence to self-examination, the emotions included in the phase are both negative and limiting. In its current form, this phase suggests that self-examination requires one to feel only negative emotions. The teachers in this study, however, did not necessarily experience such negativity as they examined their thinking around science literacy. Rather, they conveyed a sense of dismay that they had never thought to focus on teaching credibility of information and to frame science literacy as preparing their students for a future world. Consequently, this phase of self-examination should be expanded to include a wider range of emotions rather than limiting to those that are negative.

In considering these phases of transformation, the research presented here also gives evidence to certain phases being more significant than others. While the disorienting dilemma is critical to set the process of transformation in motion, the other phase that proved to be essential was phase nine: building competence and self-confidence in new roles and relationships. It was this phase that was the turning point for these teachers as they found success with the project and worked to make it their own. Moreover, that sense of confidence and ownership was essential for them to continue with their implementation and to solidify their new frames of reference around science literacy. This was also a stage that was missing in Denise's experience, suggesting that it is particularly influential in the transformative learning process.

Fostering transformation. According to Taylor (2009), there are three elements that are essential to most transformative learning experiences: individual experience, critical reflection, and dialogue. A transformative learning experience must also be authentic. For that reason, intense, experiential learning experiences are often used to promote meaning-making. Furthermore, transformative learning experiences can be time-consuming so adequate time must be given as learners move their way through the various phases of transformation. As such, SciJourn, which was designed as a community of practice sustained by ongoing meetings and support provided an ideal forum for transformative learning to occur. Schapiro, Wasserman, and Gallegos (2012) refer to such communities as the "Petri dish – the growth supporting environment- that provides both the *container* and the *space* in which such learning can occur and the *dialogical processes* through which learning unfolds" (p. 356).

As teachers were challenged to think differently about science literacy and encouraged to implement a model of science journalism in their classrooms, SciJourn's community provided the meaningful relationships that supported them through their learning process. Transformative learning involves critical reflective discourse, a form of dialogue that involves the assessment of beliefs, feelings and values (Mezirow, 2003). According to Taylor (2009), dialogue is where critical reflection plays out as learners engage with their assumptions and experiences. Critical dialogue of this form goes beyond having an analytical discussion and pushes learners to experience some "discomfort while on the edge of knowing" (Taylor, 2009, p. 10). Therefore, as a community of practice, SciJourn offered a growth supporting environment for the teachers, where they could safely try on and solidify their new meaning perspectives.

Conclusion

While this cross-case analysis has focused primarily on the four teachers who experienced transformation, it is necessary for me to also call attention to Denise's experience. Denise was the only teacher who was not transformed by the project. While SciJourn's definition of science literacy was not particularly influential for her, she did acknowledge that she focused more on teaching her students credibility than she had before. In her case, student engagement was not a defining theme because she had several students who were not interested. From her point of view, authenticity did not contribute to increased student engagement because her students already did authentic research and wrote for a real audience. That said, she did appreciate that the project was flexible and she could pick and choose what she used and how she implemented it. For Denise, some of the PD sessions were useful, particularly the experience of writing her

own article. However, she felt as though the ongoing PD sessions were not as helpful. Denise also expressed that she did not feel adequately supported in her implementation of the project despite having members of the SciJourn team visit her classroom several times. Of the teachers presented here, she was the only one who had the editor visit her classroom, yet she was also the only one who did not feel adequately supported. Her story calls attention to the fact that each teacher's experience was unique, and while the common themes presented here were seen in the stories of the four teachers who experienced transformation, transformative learning, certainly, was not universal. Transformative learning, then, is a complex equation involving individual's own unique experiences, perceptions, and needs.

The overarching intention of teacher PD is to shape teachers' instructional practices, and the majority of programs and workshops attempt to do so by teaching teachers new ways to teach. As we have seen here, however, the most critical piece of SciJourn's PD was not just focused on how teachers teach, but rather, how teachers *think*. In other words, it was the conceptual underpinnings that really influenced the teachers and facilitated a change in their instructional practices. Perhaps then, the intention of teacher PD needs to shift. For those who were transformed by the project, what set SciJourn apart from other PD efforts was not in its design, but rather, the ways the project promoted conceptual change and influenced their assumptions around science learning and literacy. In light of this, teacher PD may benefit from attending more closely to teachers' conceptions.

This model, however, requires that teachers are offered sound concepts for consideration and are invited to participate in the interpretation and revision of those

ideas. According to Larkin (2012), such a model also requires that teacher educators resist the temptation to give teachers the "right answers" (p. 28). She argues that a right answers approach will be ineffective in leading teachers to develop meaningful understandings around teaching and learning. I would add that this model, like other successful PD models, also requires adequate time and must be aligned to teachers' specific needs and interests. Most importantly, it requires that we honor teachers as thinkers and knowers.

Chapter 7: What Works for Whom?

Two cases from the previous chapter were particularly intriguing to me. As I conducted the cross case analysis, I was struck by the similarities and differences between Denise and Jessica's experiences with the project. Denise did not experience transformative learning, and during the interviews, she mentioned multiple times that she did not feel adequately supported in her implementation. However, she had gone through the summer training, attended the ongoing PD sessions, and had members of the SciJourn team visit her classroom multiple times. Jessica, on the other hand, received no support whatsoever and did not experience any PD until she had already implemented the project through her own initiative. Yet, she experienced transformative learning. Therefore, one teacher, who had plenty of classroom support to all appearances, was not transformed, while another teacher, who had no classroom support, experienced transformation. This left me somewhat confounded and led me to ask the question: Why were some teachers transformed by their participation in the SciJourn project, while others were not?

As evidenced in the previous two chapters, one important difference between Denise and Jessica's experience was that SciJourn's conception of science literacy did not resonate with Denise in the same way that it did Jessica. Denise made it clear that her perceptions of science literacy were not influenced by the project. She explained that she already knew her students needed to be able to assess credibility and know how to find accurate sources of information prior to participating in SciJourn. Jessica, on the other hand, felt that SciJourn's conception of science literacy was an exact articulation of her over-arching teaching goals, though she had never thought of her goals in that particular way prior to reading *Front Page Science.*

Another important difference that warrants discussion is what led Denise and Jessica to the project in the first place. Denise came to the SciJourn project because she was given the Authentic Science Research course to teach without any set curriculum. SciJourn, then, gave Denise a framework by which she could structure her course and provided her with a set of tools that she could draw upon. Jessica, on the other hand, was searching for a way to teach her students the writing skills that she felt they needed for college. She was confident that she had the skill-set to help her students but was unsure how to bring these skills to her classroom.

Kenneth Burke writes, "Critical and imaginative works are answers to questions posed by situations in which they arose. They are not merely answers, they are strategic answers, stylized answers" (Burke, 1974, p. 1). For Denise and Jessica, the SciJourn project provided different answers to different questions. In Jessica's case, her implementation of SciJourn was driven by an essential question: What would an authentic, engaging, science research project look like? When she started reading *Front Page Science*, she found a possible answer and decided to try it out. While Jessica was seeking answers to her essential question, Denise was looking for a toolkit of strategies that she could use to fill-in her curriculum. Jessica's concept of the ideal research project was fairly specific, needing to be authentic and engaging, and SciJourn was well-suited to meet this criteria. Denise, on the other hand, was really just looking for something to help her structure her course and to give her some sense of feeling prepared. Unlike Jessica, her participation was not driven by an essential question; thus, she did not *need* the project in the same way that Jessica did. These differences in these teachers' experiences were certainly significant. However, I suspected there was more to the story.

Hence, I returned to their narratives and probed them further in an attempt to uncover more explicitly their diverging perceptions of the project.

I returned to the transcripts from their interviews and recoded them, looking closely for moments of tension, while also attending to the similarities and differences in their stories. From that analysis, two primary themes emerged that were significant: student engagement and self-efficacy in writing. Next, I revisited the transcripts and excerpted statements that were representative of these themes (see Appendix G). From these excerpts, I then created poetic representations to paint a portrait of each teacher's story. While the excerpts are pulled from various parts of the three interviews, I have remained faithful to using the teachers' exact words. Here, I present these poetic representations by theme. I then offer my interpretations regarding the differences between Denise and Jessica's experiences.

Student engagement

Denise -

I had this new class
I didn't have a curriculum
At least I felt I had something
To get us started

These are not your average students
Independent
Specific goals
Motivation was difficult

Kids kept trying
To change their writing
But no follow-up
They needed more support

A lot would give up
I never got them to buy in

Kids thought of it
As a waste of their time
Just another thing
Another hoop they have to jump through

Jessica -

They were motivated
I set the tone
I encourage them
Lucky you for being in my class!

It's the engagement
The personal
The authenticity
Writing about something you know

I'm a kid
Let me write about myself
Let me write to understand myself
They're doing it
Something magical

Engagement
This is my choice
Big choices
Ownership

Young scholars
Motivated by personal curiosity
Learning for the sake of learning

These poetic representations of Denise and Jessica's stories illustrate their very different experiences with the project and their differing perceptions of its influence on their students. At first glance, Denise and Jessica's teaching context appear to be similar. Both teach in high-performing, suburban school districts. Their classrooms are adequately equipped and they have access to the most recent technology. An important difference, however, is that Denise teaches at the high school level, while Jessica teaches

middle school. Furthermore, Denise did not implement SciJourn in her regular Chemistry courses. Instead, she opted to only implement SciJourn in her Authentic Science Research class, which is comprised of sophomores, juniors, and seniors, who conduct independent, science experiments over the course of three years. The result was mediocre student engagement. Denise attributed the lack of engagement to the nature of the class, having above average students, and also her students not being adequately supported as they attempted to make revisions to their articles. She suggested that high performing students are sometimes more difficult to motivate than others. Furthermore, her students felt as though the project took time away from their research projects that were the primary focus of the class. Denise also indicated that because her students were high performing, the editor had higher expectations for her students but did not give them enough support and did not adequately communicate with them regarding their revisions. Consequently, her students became frustrated and eventually lost interest.

Jessica, on the other hand, had the opposite experience with her seventh graders who were highly engaged. She accredited their engagement to how she promoted the project, the authenticity of the project, and a sense of ownership on behalf of her students. She described how she intentionally endorsed the project and promoted it as being an exclusive opportunity that her students were privileged to have. Jessica also explained that the authenticity of the project was significant as it provided a real audience for her students' writing. From her point of view, the most important influence on her students' engagement was that the project cultivated a sense of ownership by giving her students an opportunity to make choices according to their own interests.

In considering these differing levels of engagement between Denise and Jessica's students there are a few variables at play. While Denise tried to persuade her students to do the project, she ultimately left the decision to them and did not give them any real incentive to participate. In contrast, Jessica heavily promoted the project and used social media to convey the project as an exclusive opportunity for her students. Perhaps the sense of ownership that SciJourn provided for the middle school students was not as significant for Denise's students because her students were already enrolled in a course that was designed as a long-term, independent study. Thus, the freedom to choose their own topic to research was not as novel or enticing as it was for the younger students. At the middle school level, students have little freedom over their schooling, whereas high school students get to choose from a variety of elective courses. Having the freedom, therefore, to choose their own topics to research was highly motivating for the middle school students as it gave them a rare opportunity to exercise some control. Denise also suggested that her students' ability-level hindered their engagement with the project, and her advanced students did not feel that the project was worth their time. While she did not implement SciJourn in her general Chemistry courses, perhaps those students might have been more engaged by the project. Of interest, these two teachers seem to view their students quite differently. Denise views her students as advanced but also resistant. Her course is designed to prepare them to pursue science-related fields, and her goal in having her students get published was that it would enhance their college applications. Jessica, on the other hand, views her students as curious people. She does not consider her class as training them to be “little scientists,” but rather, she wants to help them understand their world.

Another area where these teachers' stories diverge is in the ways they structured the project. While Denise implemented the project at the start of the school year, because of the nature of her course, her implementation was only loosely structured. In total, Denise only had six students working on SciJourn while the other six students did their independent work; she typically only used two or three SciJourn lessons a month. Jessica, on the other hand, used highly structured lessons and materials to implement the project. She introduced SciJourn at the start of the year but did not begin implementing the project until the week before fall break. After that, her students worked on SciJourn every Friday for the duration of the semester. Because her students were younger, Jessica felt that she needed to provide more scaffolds for her students so she created materials to help structure the process. Denise, however, gave her students more freedom and only offered them loose guidance as they worked through the project. Once her students had a draft, she sent it directly to the editor and let him take the lead. This may have thwarted her students' efforts as she indicated that her students struggled, particularly during the revision process. While she felt her students needed more one-on-one attention, Denise provided little structure or guidance, relying instead on the editor to do so.

Self-efficacy in writing

Denise -

> I'm not always real comfortable
> With writing
> Having to write myself
> Was a big deal
>
> Science people
> Don't really know how to write
>
> I wasn't comfortable
> That was tough

A learning experience

I'm not a writing teacher
I didn't get much back-up
Maybe it was me
I felt on my own

I really didn't know how
I would read through his edits
So I had a better idea of what I should have done

A little bit more support
Would have been good

Jessica -

I've been waiting for this project
I was looking for it

Writing has never been a problem for me
I'm a really strong writer
My confidence
That helped

I could write
I could write lab reports really well
I was good at research too

I looked at all the resources
I made them my own

Meeting other teachers
A sense of community
Gave me validation

I had to use my imagination
I was taking a risk

Rigor needs to happen
You write
You read
In every class

A cultural shift
I have the skill set to teach that

These poetic representations point to Denise and Jessica's differing perceptions of their writing abilities. This was a critical difference in their experiences with the project. Denise positioned herself as not being a strong writer, identifying as one of those "science people" who struggle to write. She also did not identify as a reading or writing teacher and did not feel that she had the time to integrate much writing into her general chemistry courses. Despite the training that she received in SciJourn's PD, she continued to struggle as her students edited and revised their articles. While she tried to read through the editor's comments to learn his approach, she never developed a sense of proficiency. As a result of her lack of confidence, Denise relied heavily on the editor to communicate with her students. Throughout the interviews, she repeatedly spoke of wanting more support and suggested that she could have used more training on how to edit. It is unclear how Denise's student population might have further perpetuated her lack of confidence. If she had implemented the project in her general chemistry courses might she have felt more confident in editing her students work? Perhaps her advanced students were strong writers and she was unsure how to improve on their writing. If she had implemented SciJourn with a more "average" group of students, she might have felt more effective in her implementation.

Unlike Denise, Jessica identified as having confidence and being a good writer; she frequently integrated writing into her science classes. Yet, it was not until SciJourn that she felt she had a writing project that met her students' needs. She intentionally made time for the project explaining that it gave her something meaningful to use to fill instructional time. She did not experience difficulties editing her students' work, and she even went beyond the level of editing suggested in *Front Page Science.* She also

developed a series of rubrics and scaffolds that helped her students to focus on specific aspects rather than trying to edit the entire article at once. For instance, they would focus specifically on editing their attributions and would only make revisions to those sections of their articles. In that way, Jessica made the editing process more manageable for both her students and herself. Her sense of effectiveness was further validated when she met other teachers who were implementing the project for the first time and they began using her materials. That community gave her the opportunity to collaborate with other like-minded teachers and offered her a sense of support. Consequently, she no longer felt isolated as she implemented the project.

Self-efficacy and Transformation

Forces influencing a teacher's professional change come from within, including his or her knowledge, beliefs, and sense of self-efficacy (Nielson, Barry & Staab, 2008). As seen in the previous chapters, phase nine, the phase of building competence and self-confidence, was particularly significant to the participating teachers' transformative learning, or lack thereof. The comparison presented here between Denise and Jessica reinforces this significance and demonstrates how their sense of self-efficacy was pivotal to these two teachers' experiences.

Self-efficacy theory. Teacher self-efficacy is a notion that has been explored over the past three decades of educational research. This work supports Bandura's (1977) theory that teachers' self-efficacy beliefs influence their ambitions, the effort they invest, and their sense of resilience when they face challenges. In light of this, teachers who do not expect to be successful are more likely to give up when facing difficulties. Bandura (1986, 1997) suggested that there are four sources that influence a teacher's self-efficacy

beliefs. These are: mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal, with mastery experiences being the most influential. For teachers, these mastery experiences stem from teaching accomplishments; their sense of efficacy is increased if they perceive their teaching as successful, which also increases the likelihood that future teaching will be productive. Vicarious experiences occur when a teacher observes another individual modeling the goal activity. The influence of the vicarious experience on the teacher's sense of self-efficacy depends on the degree to which the teacher relates to that individual. Verbal persuasion involves the verbal communication regarding a teacher's performance, which give the teacher a means for measuring his or her success. Physiological arousal refers to feelings of capability or incompetence. Teachers may feel a sense of joy when completing a successful lesson. Alternatively, a stressful teaching situation that results in anxiety may lead a teacher to feel less efficacious (Bandura, 1997).

As teachers assess their capabilities in a specific situation, they make two judgments. First, they assess the requirements of the particular task. These requirements may include resources, skills, contextual factors, and student capabilities. Next, they assess their own competence in relation to those requirements. These judgments are based on their sense of their own capabilities as well as their past experiences (Tschannen-Moran & Hoy, 2007). It is important to note that teachers' self-efficacy is context specific and thus, related to numerous school variables such as school climate, leadership within the school, as well as overall school performance (Bandura, 1997).

Self-efficacy as writers. As I explored Denise and Jessica's experiences through the lens of transformative learning theory, this notion of self-efficacy emerged as an

important construct that was critical to the process of transformation. Before I explore this further, I want first to point out that both Denise and Jessica appear to be efficacious teachers, meaning that they both believe that they have the capacity to influence how their students learn (Guskey & Passaro, 1994). Thus, their overall sense of efficacy is high. And efficacious teachers have been shown to be more open to incorporating new ideas and more willing to try to teaching strategies with the intention of meeting their students' needs (Evers et al., 2002; Stein & Wang, 1988). Both Denise and Jessica convey a sense of ownership over their classrooms and their students' learning. They also regularly seek out professional learning experiences to further their growth and development as teachers. The defining difference between them is not in their overall sense of self-efficacy as teachers, but rather, their sense of capability as *writers* and *writing teachers.* This is an important distinction because much of the research around teachers' self-efficacy focuses on their generalized sense of their teaching performance, rather than their sense of self-efficacy in teaching particular subjects.

> Teacher efficacy has been defined as both context and subject-matter specific. A teacher may feel very competent in one area of study or when working with one kind of students and feel less able in other subjects or with different students. While researchers and theorists agree that teacher efficacy is situation specific, it is less clear what is the appropriate level of specificity (Tschannen-Moran, Hoy, & Hoy, 1998, p. 215).

For the purposes of this study, the level of specificity is vital because both Denise and Jessica are efficacious teachers. However, their perceived self-efficacy as writers, and writing teachers, is distinctly different.

If we look to Bandura's (1977) theory, he suggests that an individual's beliefs regarding his or her efficacy are influenced by four sources: mastery experiences, vicarious experiences, verbal persuasion, and physiological arousal. The first source, mastery experiences is when an individual feels successful in accomplishing a desired outcome. In Denise's case, she never developed a sense of mastery in implementing SciJourn in her classroom. She came to the SciJourn project doubting her abilities as a writer. Her lack of confidence was further perpetuated when she took the project back to her classroom and found herself struggling to edit her students' work. Furthermore, her students were not engaged by the project and she had difficulties motivating them to participate. Consequently, she never felt successful in her implementation of the project. According to Bandura (1977), the rise in efficacy beliefs causes subsequent expectations of being successful and increases an individual's desire to persist in the face of challenges. In Denise's case, though she tried to implement the project over the course of two years, she never developed a sense of proficiency and continuously struggled. Though she did ask for help, she did not feel that she received adequate support and eventually became frustrated and gave up on the project.

In contrast, Jessica's sense of efficacy as a writer was high before she found SciJourn. Because she felt comfortable teaching writing, she intentionally built meaningful writing activities into her science classroom early on as a teacher. And while Jessica often referred to herself as a "baby teacher," it was clear that she felt confident in her teaching ability, which was evidenced by her motivation to play an active role in her district. For example, when she first arrived at her school, she did not like the textbook she was given nor the curriculum that she used. So, she took it upon herself to create an

entirely new scope and sequence and wrote a new science curriculum for her district. She also conveyed a willingness to share her ideas and resources with other teachers. Upon finding the SciJourn project, Jessica took the risk and implemented it in her science classes without any external support. Because she was a strong writer, she felt that she was adequately equipped to develop SciJourn teaching materials and also to edit her students' work. When in doubt, she called upon a colleague, a language arts teacher, to look over her materials and offer her feedback. Additionally, her students' positive responses and authentic engagement reinforced her sense of success. As a result, she continued with the project, continuously tweaking her implementation and working to overcome various challenges along the way.

The second source of influence on an individual's sense of self-efficacy is vicarious experiences, which suggests that self-efficacy is greatly influenced by the extent to which individuals perceive themselves to be similar to others who model desired outcomes (Bandura, 1977). In Denise's case, while she wanted to become proficient at editing, the editor's expertise seemed outside the realm of her capabilities. So rather than feeling as though she could improve, her sense of self-efficacy was further diminished when she could not model his editing process. While Denise valued the community of teachers that she encountered in SciJourn's PD, she also recognized that her student population was more advanced than most, so she likely did not identify with many of the teachers who found success with the project. Unlike Denise, Jessica did not have any interaction with the editor until she had already implemented the project and worked through the initial round of editing her students' articles. In other words, she had already developed a sense of success in implementing the project prior to interacting with

any of the project staff or other teachers. Rather than relying on other individuals for support, *Front Page Science,* was the primary tool that she used. When she joined SciJourn's PD, she was interacting with teachers who had yet to implement the project in their classrooms so she was viewed as the experienced teacher rather than a novice. This also reinforced her sense of efficacy.

The third source of efficacy is verbal persuasion, where a teacher receives verbal feedback on his or her performance (Bandura, 1977). In Denise's case, the primary feedback that she received from her students was a lack of motivation and mediocre engagement. This was accompanied by communication from the editor that her students were not making the suggested revisions. Together, these messages perpetuated her frustration with the project and led her to doubt her implementation. Jessica, on the other hand, received positive feedback from her students, the editor, and the teachers she met through the PD where she shared her resources, which reinforced her sense of being successful.

The fourth source of efficacy is physiological arousal, which refers to the emotions that an individual feels when he or she feels capable or incompetent in an endeavor (Bandura, 1977). Denise repeatedly expressed her sense of frustration with the project during her interviews. Several variables contributed to these feelings but her students' lack of engagement and her lack of self-efficacy as a writer were the most significant. For Jessica, the project was life changing and transformed her classroom. Thus, her sense of competence was reinforced through her students' enthusiasm and her own sense of confidence as a writer.

As I sought to understand more deeply the differences between Denise and Jessica's experiences with the SciJourn project, both the students' level of engagement and the teacher's sense of self-efficacy as a writer proved to be important influences. Moreover, the students' level of engagement seemed to contribute to each teacher's sense of self-efficacy, or lack thereof, as she worked to implement the project. As we have seen, Denise expressed a need for stronger support and more guidance in learning to edit her students' writing. This aligns with findings from a previous study that suggests during the first year of an initiative, teachers often view themselves primarily as learners and thus, feel a need to rely on external support (Nielson, Barry & Staab, 2008). By the end of the first year of that initiative, however, many teachers were beginning to shift from learner to change agent. That shift was further enhanced as the initiative moved into its second year. The key element that influenced the shift was the teacher's sense of self-efficacy regarding new ways of teaching. As they moved from learner to change agent, their focus transitioned from themselves as learners to their students' learning (Nielson, Barry & Staab, 2008). As seen here, in Denise's case, she was never able to move beyond the role of learner as she struggled to adapt the project to her specific context.

In Jessica's case, finding a community of like-minded teachers was particularly influential and reinforced her sense of capability. This aligns with the work of Tschannen-Moran and Hoy (2007) who suggest that the support of colleagues and community are particularly important to the self-efficacy beliefs of novice teachers. They argue that experienced teachers have adapted to working in isolation and thus, base their efficacy judgments on other sources. Denise and Jessica's experiences with

SciJourn reinforce these findings. While finding the SciJourn community was vital for Jessica, Denise did not perceive community as being essential.

Self-efficacy and transformative learning. This portion of the study sought to answer the question: Why were some teachers transformed by their participation in the SciJourn project, while others were not? The primary difference between the two cases presented here were the grade level of the students, the level of student engagement, and each teacher's sense of self-efficacy as a writer and writing teacher. Furthermore, the grade level and degree of student engagement proved to be intricately tied to the teachers' self-efficacy as they worked to implement the project.

These teachers' experiences suggest that developing a sense of efficacy is critical to transformative learning. This strengthens the importance of phase nine in the stages of transformation, where the learner builds competence and self-confidence. Thus, in order to foster transformative learning, special attention should be paid to nurturing learners' sense of efficacy and giving them the opportunity to develop mastery experiences. As we consider the design and facilitation of teacher PD, this notion of self-efficacy becomes essential. As Tschannen-Moran and Hoy (2007) write, "Teachers' self-efficacy is a little idea with a big impact" (p. 954). Thus, PD should aim to develop mastery experiences where teachers can garner a sense of success and build their confidence. Furthermore, it would behoove teacher educators to provide the kinds of learning experiences and supports that would nurture the development of teachers' perceptions of self-efficacy as it relates to particular learning outcomes.

Conclusion

As I close this chapter, I want to acknowledge that as an educator, I can relate to both Denise and Jessica's experiences. I have made clear that my own experience with the SciJourn project was positive. Like Jessica, I also identify as a strong writer, and I was particularly influenced by SciJourn's conceptualization of science literacy. Denise's perceptions, however, are reminiscent of my own experiences with teacher PD that left me feeling frustrated and ineffective. I often pushed back (and still do) against PD that was not well-matched to my particular needs. I struggled when I was forced to attend workshops on tools and strategies that were not well-suited to my teaching context or my population of students. I also resisted PD that made me feel vulnerable. Three years into my teaching, I did a summer research project in a neuroscience lab at a local university. The intention was that I would translate my learning into lessons or projects in my biology classroom. The outcome, however, was quite different. Much of the work in the lab required an expertise that was outside of my realm of experience and knowledge. My sense of self-efficacy was diminished as I struggled to make sense of the research I was meant to be doing. I never applied that work in my classroom in any way. Not because I did not want to, but because I did not know *how*. This did not mean that I was incapable, but rather, I just needed a different learning experience than the one I had been provided. And, like Denise, I felt that if I had had more support, the outcome might have been different.

The poetic representations presented here illustrate that Jessica fell in love with the SciJourn project, while Denise did not. Perhaps Denise would have found greater coherence with a project that focused on research writing, aligning more closely with her specific context and needs. In the end, SciJourn simply did not resonate with Denise, nor

did it provide her with strategic answers in the same way that it did Jessica. Acknowledging that PD must speak to a teacher's individual needs is an essential piece of the puzzle and is critical to research that tries to understand why PD works or does not work for different individuals.

Chapter 8: Conclusion

In this study, I sought to understand the influence of participation in the SciJourn project on teacher participants. More specifically, I wanted to explore what aspects of the project influenced teacher transformation, the ways teachers were transformed, and why some teachers experienced transformation and others did not. In this multiple-case study, I have looked closely at the stories told by five teachers and considered the commonalities and differences in their experiences and perceptions. These five teacher participants are all science teachers who implemented the SciJourn project in their classrooms. Two of them are male, and three are female. They have varied levels of experience, teaching in both urban and suburban schools. Three of them teach high school, and two of them teach middle school. Four of these teachers were selected for this study based on their responses on a survey that was given at the end of the project. The fifth teacher was selected because she was a unique case who found and implemented the project after reading the book *Front Page Science.*

In this final chapter, I revisit my research questions and my findings. Next, I discuss the implications for practice. Then, I reconsider the three dimensional conceptual framework that guided this study and make suggestions for further research.

Research Questions

The following research questions guided this project:

- How did the SciJourn project build professional community and influence transformative learning?
- How did participation in the SciJourn project influence science teachers' professional identities, knowledge, and classroom practices?

- In what ways were teachers transformed?
- Why were some teachers transformed by their participation in the project, while others were not?

These questions were derived from my own personal experiences with teacher professional development. As detailed in the introduction, most of the PD I experienced as a classroom teacher was ineffective and irrelevant to my specific teaching context. Later, when working as an instructional coach, I became particularly interested in teacher learning and sought to understand more clearly how teachers are influenced to change their teaching practices. This interest was further perpetuated by my own positive experience with the SciJourn project. From my point of view, there seemed to be something profoundly influential about SciJourn, and I wanted to explore it in more depth. I knew that under the surface of teachers' praises, there had to be more nuanced perceptions, and within these nuances, I hoped to uncover the ways SciJourn was or was not transformative for participating teachers.

Interpretations

The making of SciJourn. In chapter four, I explored the SciJourn project within the context of current scholarship on science literacy and writing in science. I also examined how SciJourn derived its own, innovative conceptualization of science literacy and the ways the project was intentionally designed to facilitate teacher learning. Of importance, was SciJourn's definition of science literacy as the skills students will need to successfully deal with the science-related issues they may encounter 15 years beyond high school graduation. This vision of science literacy was a platform that not only resonated with educators but also pointed to one of the fundamental goals of science

education. It evolved into SciJourn's conception statement and came to contextualize the entire project.

Chapter four also illustrated how SciJourn's PD was deliberately created to foster community and to empower teachers. The literature presented in chapter two gave several criteria for productive PD. If we look to Engle's (2010) four principles for successful collaboration, we can see that SciJourn characterized all of them. The project brought a diverse group of learners together to share in the design and implementation of a new approach to teaching science literacy. Throughout the project, participants were valued and treated with dignity and respect. Teachers were given a voice and the project was built to center around their expertise. Collectively, the participants took ownership over the project, fostering a sense of internal accountability, and they shared resources and best practices during the PD sessions and through teach4scijourn.org. Additionally, if a teacher was struggling, he or she had multiple outlets for support and assistance.

In light of increasing demands and accountability, it is more important than ever that we provide teachers with the kind of PD that not only meets their individual needs but also empowers them to work successfully within today's complex educational system. Ultimately, the perspective of PD that was most prevalent in designing SciJourn was the perspective that we learn best in community and when it comes to classroom practice, teachers are the experts. Teachers have built expertise through their experiences. They know their students. They know the practicalities of working in school systems, and they know what it means to facilitate learning on a daily basis in and around classrooms. Therefore, their insights are essential for any project that aims to influence teaching practice and student learning. Essentially, SciJourn provided teachers

an authentic learning experience that honored them as learners and professionals, while also giving them a voice to construct their own knowledge and develop their own meanings.

Teacher transformation. Of the five cases presented in this study, four of the teachers experienced transformative learning through participation in the project. This transformation was identified as a change in these teachers' stories to live by, characterized as an identity shift. Thus, each of these teachers experienced a change in his or her professional identity that was triggered by participation in SciJourn. In this way, these teachers' perceptions of themselves and their roles as teachers were altered. While SciJourn influenced them to think differently about teaching science literacy, they also began to think differently about the ways they teach content, focusing not just on how they teach but what they teach. Amongst these four cases, three predominant themes emerged across their stories: a changed conceptualization of science literacy, the importance of student engagement and authenticity, and the value of SciJourn's PD.

While all four teachers were influenced by various aspects of the project, their changed conceptualization of science literacy was particularly salient as it resulted in a reframing of their meaning perspectives around science literacy. SciJourn's definition challenged these teachers' assumptions, led them to rethink how they teach science literacy, and also influenced them to re-evaluate their teaching priorities beyond the PD. This shift in their meaning perspectives was essential, functioning as the trigger that set into motion the process of transformative learning.

Student engagement and the authenticity of the project were also significant to these teachers' experiences. As each of these teachers worked to implement SciJourn in

their classrooms, their students' positive response was vital. As the teachers witnessed their students becoming invested in the process of researching and writing, they came to see the project as a meaningful learning experience. For these teachers, the level of student engagement was markedly higher than usual and thus, motivated them to continue with the project even though they sometimes struggled with implementation. Three of the four teachers also felt that students' investment was closely linked to the authenticity of the project, as it gave them the opportunity to investigate real, and oftentimes, personal issues while writing for a real audience.

The third common theme found across these teachers' stories was the importance of the PD, which played an essential role in their transformations. The PD not only equipped the teachers with the tools and skills needed for implementation, but also provided them with a community and network of support. The ongoing PD sessions were particularly important as they gave teachers the opportunity to hear other's stories and inspired them to continue working through their difficulties.

While each teacher's experience and perceptions were unique, these three common themes point to the most influential parts of the project for these particular teachers. Nonetheless, not all teachers shared the same positive outlook on the project. Chapter seven explored more closely the diverging experiences of two teachers. What emerged from that analysis was the importance of student engagement and also the influence of the teachers' sense of self-efficacy as writers. That analysis also suggested that teachers must find coherence with PD efforts and feel as though those efforts are well-matched to their particular needs.

Implications for practice

Though I tried to refrain from making a hypothesis, when I first began this study, I suspected that SciJourn's PD was the driving force that led teachers to transform their teaching practices. What I found, however, is that while the PD was important, there were other crucial variables at play. SciJourn's conceptualization of science literacy, which offered a different and authentic vision of science literacy, was foundational. That definition resonated with teachers in a powerful way and hooked them into the project. And while SciJourn provided teachers with a toolkit of strategies, the details of implementation were always secondary to the ideas.

This is notably different from most teacher PD. This was not a pre-packaged approach, but instead, teachers were given the freedom to implement the project in their own way. The PD also provided the community that helped the teachers to feel supported and motivated them to keep working through their struggles. Therefore, SciJourn's PD provided the space for these transformations to happen, but it was the conceptual understandings that hooked the teachers, challenged their assumptions, and led them to reframe their ideas around science literacy and also science teaching. As a result, a paradigm shift occurred where these teachers were not just thinking about how to teach science journalism but were also rethinking everything they were doing in their classrooms.

The importance of creating a community of learners in professional development is well-documented in the research literature, but there is little discussion on influencing teachers' assumptions around teaching and learning. Perhaps PD efforts, and teacher education in general, should focus as much, or more, on influencing teachers' ideas

regarding *what* and *how* they teach and less on teaching strategies. As seen in this study, if conceptions are shifted, then a change in teaching practices will likely follow. Therefore, attending to the ways teachers think about teaching and learning should be a critical piece of the conversation around reform efforts and teacher PD.

Another important implication that emerged from this study is the idea that PD, in order to be successful, must somehow speak to a teacher's individual needs. As seen here, each teacher brought along different dilemmas as well as different backgrounds and teaching contexts. For those teachers who were transformed, SciJourn provided them with a new approach to teaching science literacy that aligned with their specific wants and circumstances. This supports the work of Flint, Zisook, and Fisher (2011), who call for PD that positions teachers as individuals with specific needs. For PD to be successful, then, it must be well-matched to teachers' individual teaching contexts and interests.

Finally, student engagement played a significant role in teachers' perceptions of the value of the SciJourn project. This suggests that whether or not teachers sustain a new practice is closely tied to their students' feedback. Additionally, a teacher's sense of efficacy in implementing a specific reform effort is of consequence. Aside from wanting to implement a project, a teacher also needs to believe that he or she is capable of successfully doing so. In light of this, reform efforts and teacher PD should continue to explore ways to nurture sustainability and support, both of which are essential to teachers' success.

Revisiting the conceptual framework

While Mezirow's transformative learning theory was the primary analytical lens used in this study, I also drew upon sociocultural conceptions of practice and sociocultural conceptions of identity. I integrated these three conceptual frameworks to help me better understand the process of transformative learning. One of the debates within transformative learning theory is around the question, what form transforms? In this study, I have utilized Kegan's (1994) perspective that transformative learning changes the *form* of oneself. In other words, I considered transformative learning as influencing an individual's identity. Therefore, I drew upon elements of sociocultural conceptions of identity to help discern if teachers had been transformed and in what ways. From my perspective, the blending of these two theories provided me a more concrete way of determining when and if transformative learning had occurred and thus, strengthened this study.

Similarly, one of the criticisms of transformative learning theory is that it places too much emphasis on the individual and neglects the social and contextual nature of transformation (Taylor, 2012). To address this criticism, I also drew upon elements of sociocultural conceptions of practice to help me understand the ways SciJourn's community influenced teachers' transformations. What I discovered was that transformative learning was a highly individualized process, dependent on each teacher's background, experiences, and needs. Yet, SciJourn's community also played a significant role in the process. Therefore, while transformative learning is indeed individual, it is embedded within and dependent upon social and contextual factors. Combining these

two theories, then, provided me with a deeper understanding of the context of SciJourn and the ways it influenced teachers' transformations.

Overall, I found transformative learning theory to be particularly useful in exploring the influence of the project on teachers. As a theory in progress, however, I see some areas where the theory could be strengthened. In the cases presented here, transformative learning was dependent on the teachers' reframing their meaning perspectives around science literacy, which resulted from a new conceptualization of science literacy. This finding is congruent with Whitney's (2008) research on teacher participants in the NWP where she found that reexamining meaning perspectives was at the heart of teachers' transformations. The ten phases of transformation (Mezirow, 2000) are well-documented as part of transformative learning theory, and the scholarship suggests that not all transformative learning experiences necessitate all ten phases. On the other hand, there is little conversation around the weight of certain phases over others. The research presented here, however, suggests that certain phases may be crucial. For each of the teachers who experienced transformation, phase three, critical assessment of assumptions, was significant. These teachers' assumptions were challenged as they were introduced to a new frame of reference that positioned science literacy as preparing students to navigate scientific information in their future world. Phase nine, building competence and self-confidence, was also critical as they worked to successfully implement the project and make it their own. In the case of Denise, who was not transformed, she never critically assessed her assumptions around science literacy and was unable to build the competence and self-confidence that was necessary for phase

nine. Consequently, her meaning perspectives were not reframed. In light of this, further research into these ten phases and their significance could help strengthen the theory.

Suggestions for further research

There are many different opportunities for future research that could stem from this study. First, since this study began, the SciJourn grant has come to a close. Therefore, the question arises: In what ways do teachers sustain implementation of SciJourn after the project comes to an end? While certain elements of the project are still being implemented in various courses and as part of other PD initiatives, the print newsletter, the *SciJourner,* is no longer in print, the PD sessions have come to a close, and the project staff have moved on. Thus, an interesting follow-up study to this one would explore the ways teachers are continuing to implement elements of the project in their classrooms without these structures in place. Second, the teachers in this study made it clear that their implementation was continuously changing and evolving. A follow-up study to this could follow these teachers longitudinally, over time and explore the ways they continue to embed SciJourn principles into their teaching.

Here, I looked in-depth at the influence of the project on the teacher participants, but many other questions arise from this work. What was the influence of the project on student participants? Were students of different grade levels or backgrounds influenced differently? Did a teacher's conceptual change around science literacy result in a conceptual change for his or her students? Another avenue of research might consider if the researchers or designers of the project were somehow transformed. Of the teachers in this study who attended the summer workshops, all four of them suggested that writing their own article was meaningful. I have only briefly touched on that theme in this study;

thus, a follow-up study could explore that experience in more detail. Similarly, in my comparison of Denise and Jessica's experience, I saw that the two teachers seemed to perceive their students and their roles as teachers differently. Future studies could look more closely at teachers' perception of how their students learn and the ways these perceptions influence their implementation of reform efforts. Finally, designing an alternative kind of PD that aims to influence teachers' assumptions around teaching and learning is certainly worthy of more research.

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Appendices

Appendix A: Pilot Study Interview Protocol

- This is a picture that you drew at a PD session 2 years ago illustrating your experience with implementing SciJourn in your classroom. Can you please explain the picture to me?
- Possible follow-up questions:
    - Tell me more about how you implemented SciJourn
    - Why did you choose to implement SciJourn in this way?
    - How did your implementation of SciJourn change from the first to second year (second to third year)?
    - What have you learned that might help others implement SciJourn in their classrooms?
    - What do you hope your SciJourn implementation will look like in the upcoming (next) year?
    - How did SciJourn impact the way you teach science content?
    - Anything else you would like to add?

Appendix B: SciJourn Teacher Survey 2013

Name:

How many years have you been teaching?

How long have you been doing SciJourn?

What subjects have you used SciJourn in?

What grade levels have you used SciJourn in?

Likert Questions

For each of the following statements, please select the appropriate box. Please use the comment box to add any clarifying information you think is necessary.

	Not at all	Slightly	Moderately	Significantly	Comments
SciJourn has influenced how I think about science literacy					
SciJourn has impacted how I think about science writing					
SciJourn has influenced my teaching goals					
SciJourn has impacted my instructional practices					
SciJourn has impacted my teaching					

philosophy

SciJourn has
influenced
how I engage
with my
students

Free Response Questions

1. To what extent are you implementing SciJourn this year?
2. How has your implementation of SciJourn changed over time?
3. How has SciJourn influenced your understandings of science literacy?
4. How has SciJourn influenced your instructional practices?
5. When you think of your teaching five years from now, what elements of SciJourn do you think you'll still be incorporating into your teaching?
6. When you think back on your SciJourn experience, what was the most important thing that you learned that you will carry with you?
7. What were the strengths of SciJourn's professional development?
8. What were the weaknesses of SciJourn's professional development?
9. What knowledge/skills did you hope students would get out of SciJourn?
10. What knowledge/skills do you believe students actually got out of the experience?
11. Have you shared SciJourn with other teachers in your school or department? If so, please explain:
12. Would you be willing to be interviewed about your experiences with SciJourn? If so, please fill in your contact information:

    Phone:
    Email:

Appendix C: Revised Teacher Interview Protocol

The First Interview

Explain: *This first interview has to do with your experiences as a science teacher up until your participation in the SciJourn project.*

Initial question: "Why did you become a science teacher?"

Topics that I would like to see covered in this interview are:

- Meaningful experiences that led to an interest in science
- Meaningful experiences that led to an interest in education
- Other careers before teaching or careers that were considered
- What a good teaching day looks like for you as a teacher
- What a bad teaching day looks like for you as a teacher
- Professional identity (strengths and weaknesses)
- Context of local teaching environment
- Professional development experiences (prior to SciJourn)

The Second Interview

Explain: This interview will focus on your experiences as a teacher participant in SciJourn.

Initial question: "Describe what it was like to participate in SciJourn"

Topics that I would like to see covered in this interview are:

- Perceptions of the professional development sessions
- Implementation (past and present)
- Challenges and successes with the project

- Stories about classroom experiences (positives and negatives)
- Reasons for participating in SciJourn

The Third Interview

Explain: This interview will provide an opportunity for you to reflect on your SciJourn experience.

Initial question: "What, if anything, did you take away from your participation in the SciJourn project?"

Topics that I would like to see covered in this interview are:

- Influential qualities of the project
- Future implementation
- Impact on teaching philosophy and beliefs about teaching
- Impact on classroom practices
- Influence on professional identity

Appendix D: Researcher Interview Protocol

1. How did you approach the process of designing the professional development for SciJourn?
2. What were your priorities for the professional development process?
3. How were teachers recruited for the project?
4. Tell me about the first summer institute.
5. How was the second summer institute different from the first?
6. How was the third summer institute different from the second?
7. Describe to me the different forms that the professional development took.
8. Sum up for me how the professional development process evolved throughout the duration of the project.
9. What surprised you about the professional development process?
10. From your perspectives, what were the most influential components of the professional development process?
11. What were the most influential components of the project as a whole?
12. Tell me how teachers were supported beyond the professional development sessions.
13. How much influence do you think the professional development had on teachers' implementation?
14. When you think of the teachers who were highly involved in the project, what can you tell me about them?
15. What about those teachers who were not highly involved?

16. What did you learn from the teachers as they began implementing the project in their classrooms?
17. Do you feel that the project was a success? Why or why not?
18. If you were able to go back and do it again, what would you change?

Appendix E: Teacher Interview Code table

Code:	**Description:**	**Example:**
Accountability	Feeling a responsibility to implement the project	"I also wanted to do well for Wendy and Alan. I think they made you want to do well for them because they were putting so much of themselves into this, that they really believed in what they were doing."
Authenticity	Having a real world audience beyond the classroom	"I'm confident that student writing increases in quality when students know other people besides the teacher are going to be reading it."
Barriers to implementation	Struggles with implementation of the project	"I was like almost in survival mode for a half a year trying to get up and running. So I think the school dynamics really kind of hurt the article writing aspect that I wanted to do."
Career influences	Factors that led to science teaching career	"However, once being in the lab I noticed that I did not enjoy being in a lab day to day to day to day doing science work. I love science, but the tediousness of the lab kind of turned me off."

Community	Feeling a sense of community with SciJourn teachers and team	"I loved coming back into that positive atmosphere. You just don't see that everywhere, where you feel like you're coming home. You feel like you're with like-minded people. That everybody's there to learn and to get better and to share what worked and what didn't."
Credible sources	Importance of teaching students how to identify multiple, credible sources of information	"If you do a Google search and you search for a topic and you come up with 500 websites. It's learning how to sift through those 500 to see which one is the best."
Definition of science literacy	SciJourn's definition: skills students will need 15 years beyond high school graduation	"I want them to be ready to critique, analyze, form their own opinion, on science issues 15 years out. You know, I know I'm using that from SciJourn, but I think that that's the most valuable skill students can have."
Engagement	Level of student engagement with the project	"I sort of knew that as soon as I really unleashed the project something magical might happen. And I was just like, whoa. The class is completely silent and they were authentically engaged."

Flexibility	The ability to adapt the project to individual teaching context	"So, the fact that the program allowed you to do what you needed to and fit it to your class made it much more reasonable or made it much more valuable for me as a teacher."
Front Page Science	Referring to SciJourn's publication	"I would ask them the questions the book tells the teacher to ask, like, why are you interested; what makes you interested in this topic?"
Future career path	Current or future position	"Next year I'll be running a Makerspace. And I think this is my dream job. It's sort of a culmination of everything I've been working towards."
Infographics	Using Infographics as a part of implementation	"I found that doing infographics allowed me to hit the content and allowed them to use their literacy skills, but they have a smaller, more compact-type project that they could work on and actually get it done quicker than if they were writing a paper."
Lack of support	Not feeling supported in implementation	You know, I mean, I think I always felt like once I walked out of the door, I was on my own. It would have been nice if even someone might have called or emailed and said, "Hey, can we just stop by?" instead of waiting for us to make an appointment.

Making it own	Revising implementation to fit individual needs	"For many of my English language learners, they would decide on a topic and have trouble finding accessible websites for that topic. For some of my lower level English language learners, I opted to do the caption project with them instead."
Irrelevant professional development	Negative professional development experiences that are not applicable to teacher's needs	"Things that the district felt that I need didn't work out because most of the time I didn't need it."
Relevant PD	Professional development that is practical and meets individual needs	"There was great care in making sure that it fits within your curriculum, fits with what you're doing in the class, not just adding something extra, it's enhancing your instruction."
Support	Feeling supported in implementing the project	"There were people there all along the process, during the professional development and afterwards saying 'Hey, let me help you. If you're having problems, I can help you in doing this, I can help show you some techniques, I can give you some pointers.'"

Teaching context	Characteristics of teaching context (school and district)	"I had students in my class who were reading at a second grade level in an 11th grade chemistry class; both native English speakers at the second grade level and English language learners at the second grade level."
Professional identity	An ongoing construction of what teachers see as important in their professional work	"There is very little lecture. That's part a personal thing. I just do not like standing up in front of the room. But also because I've seen the power of when students are collaborating what that can lead to."
Writing in science	Writing assignments and instruction occurring in science classrooms	"We tried a brochure once. Um, you know, like fire safety or those were just – I thought they were useless, um, and not very creative."

Appendix F: Project Designer Interview Code Table

Code:	**Description:**	**Example:**
Classroom support	Visiting classrooms to support implementation	"Usually they invited me for the topic selection and I would do pitches."
Co-construction	The role teachers played in co-constructing the project and the PD	"Teachers are smart and they need to be treated as smart and as co-creating what it is that we do."
Editing	Editing news articles	"Alan's edits are what I call 'actionable'."
Guidelines	Referring to SciJourn's guidelines	"What we needed to be able to do is show what our guidelines answered.
Journalism identity	Identifying as a journalist	"We wanted people to authentically view themselves as able to deal with multiple, credible sources, understand attribution, and know what's a good topic."
Professional development design	The intentional design of the PD	"There are three parts of any PD: one you need to model something, two you need to unpack it, and third you need to apply it."

Professional development changes	Revisions to the PD	"We started collecting these war stories and revising things. It was Laura who first said 'these kids don't know how to search' and that led to the instruction we do on searching."
Purpose	The overall intention of the project	"If we could influence policymakers on this, as well as teachers, and I think that's what the book and our articles have attempted to do."
Role of journalism	The influence and role of journalism	"It came from my sense of journalism, I realized that anything you teach in the moment becomes dated."
Science identity	Identifying as capable in science	"Am I a science kind of person?"
Science literacy	SciJourn's definition: skills students will need 15 years beyond high school graduation	"You don't want to just know what is happening in chemistry, or biology, or physics. You really want to know what can we teach them that will have meaning fifteen years out."
Teacher authority	Teachers as experts	"What we've learned over and over again with SciJourn is how much you learn from being in the class with teachers."

Appendix G: Thematic Excerpts from Denise and Jessica's Interviews

Denise - "Getting them to be motivated was difficult"

I had this new class I was teaching
That I really didn't have a curriculum for
So at least I felt like I had something to present to these kids
That would help get us started

This class is a three year course
I had sophomores
I had juniors
I had seniors

Kids felt like it was a waste of their time
And I guess I understand that
Because the kids that I would get in this course
Are not your average students

Most of them are above average students
And those types of children didn't feel like
That's what they needed to be doing
So getting them to be motivated was difficult

However, some of the kids
That I thought would not do as well
Because they're more of the average student
Actually did better with that project

So it really kind of was different
Than what I thought it would be
Which I thought was cool at the same time
The ones you wouldn't expect to do so well
Did much better

The older kids
I really feel like I never really got them to buy in
But they had already been in this class a year or two
And had specific goals that they had set

And I understood that, you know
This was probably a little behind what they had already done

A couple of them tried

But they had their own goals
Like I said, it's an independent learning class
So I couldn't really deny them to do the work
That they had already planned

I think at least half of them were published eventually
It took a little while to get through the revisions
And do everything that the editor wanted

The kids that I have are probably a little more upper level kids
Than a lot of people might have had
And so I almost felt like
Since I had those better students
That they expected it to be easier for those kids

That I shouldn't be having any issues
That I should be getting better work
I'm not saying anybody ever actually said that
But that's the impression I got

Where, in all honesty,
If you're teaching those kinds of kids
Sometimes they're harder to motivate
They're harder to get to change the way they think
And you might have trouble getting them to do things

I just think that there were certain expectations
That they wanted to happen
And if the kids weren't producing that
then they weren't really responding to them

The kids felt they kept trying to do things
To change their writing
And understand what they wanted
Some of them did really well at taking that advice
and some of them did not

That's when a lot of them would give up
And I feel like that was because they didn't get a follow-up

Or I would get the email back saying,
"They didn't do anything different."
And I would be like,
"Well, maybe they didn't understand"
You know, I'm not sure

I just felt like that was the kind of thing
That maybe they needed a little more one-on-one support

Some of them could have cared less about the project
I told the kids, "Think about it this way
When you go to apply for colleges
You can put down
That you have a published article in a science journal"

I think that should be an incentive
But some of them were like,
"Yeah, I've got other things that are just as important, if not better."

Kids thought of it as just another thing they had to do
That's another problem with some of the upper level kids
It's just another hoop they have to jump through
And didn't like doing it

If they didn't like it
It was because it was just something
That adds onto what they had to do for the course

The idea behind the course is that they find a topic
They research it
They perform an experiment
They do this whole scientific process with it
And then, in the end, they have to present that

The presentation part is very formal
So for them, it was good that first year
And they've said that, too
It was good to learn the basics of how to do research
How to find credible sources
How to determine what's good, what's bad.
That part was good

But then, the following year
I think they felt like they didn't have the time
To spend writing that style
When they knew they had this other style
This rigid, science journal article type of writing
That they had to do

Jessica - "They're motivated by personal curiosity"

They were motivated
I really set the tone
We talked about why I want to do this project with them
And what can they get from it

I encourage them to share their projects
In unconventional ways
That their parents don't like, probably
I put it in the newsletter
This year I tweet about it
I try to make it cool

I try to make it like this exclusive thing
Because if the rest of the school ain't going to take it on
I'm going to make it this exclusive thing
That's happening to you in my class
Lucky you for being in my class!

I sent an invitation for all kids to publish
If you want to, you must be committed to revising
So about five kids submitted theirs to be revised
They got feedback
Only one kid actually finished it

My grading is way more focused on the process
It's checkpoints
They had as many points last year for just completing the checkpoints
As they did the final product
The final product was easy to grade

These authors of the book subscribe to the idea
That every child should be scientifically literate
Which is really just an offshoot of information literacy
And so the child's right is to information literacy

If my kids take that from my class
I've taught them everything
I would ever have dreamed to teach them

How to use information
How to understand it
How to understand your world
How to figure out more about it

How to write

But it's the engagement piece
The kids don't even care
That they're doing research when they're doing SciJourn
They're just doing it

It's the personal piece
And the authenticity of the project
So you're writing about something you know
The research is there

But I'm a kid.
Let me write about myself a little bit
Let me write to understand myself
You know, kids should have that right

They're scholars
But they're young scholars
And the authentic audience
I couldn't give it to them
SciJourn gave it to them

And I don't know that they're even motivated by that
So much as the personal angle
They're motivated by personal curiosity
That's authentic engagement

Authentic engagement is learning for the sake of learning
They're doing it for the sake of doing it
And their curiosity

I sort of knew that as soon as I really unleashed the project
Something magical might happen

And I was just like, "whoa"
The class is completely silent
And they were authentically engaged

The kids were into it
And so I made the time
And it was really worth it
Plus they like it
And they're actually using the Internet for real things

I felt like it could be authentically engaging

And I felt like it could help kids push themselves beyond their lexile
Or beyond their measured abilities
And it did

I knew once we started
The kids got into the research
That we were going to have authentic engagement
And it did

It was all quiet
There was just the typing
And they were just in it
They were researching

So yes, the engagement
I wouldn't keep it if it wasn't engaging
I would never drag the kids
Through four and a half weeks worth of stuff

Never, never, never would I do that
I teach engaging
I try to engage the kids every single day as much as possible
That's a number one consideration

Even though sometimes, I don't get them
But this project gets them
If they put something into it
They get that thing out of it times ten

So yes, engagement
Choice.
Big choices
I don't restrict them at all

The ownership is there
Like, hey, this is my choice
It's not my teacher's choice
It's not this kid's choice

The only person who chose this is me
So therefore it's my project
It's not the science class project
This is my project

Denise – “I’m not always real comfortable writing"

I'm not always real comfortable with writing
Having to actually research and write myself was a big deal
And that, to me, was a real eye opener

I was right back in that student seat
Learning how to do something that I wasn't comfortable with
That was tough
Because I felt like I wasn't prepared

And the editor was quite tough
But had great criticism
Even though it was hard to hear sometimes
I think I went through three revisions

I think in general
Science people don't really know how to write

I was the first one in my group to be published
I was very proud of myself
I worked pretty hard on that

I may have bit off more than I can chew
I wish they would have came more
Maybe I didn't request that enough

Not that I couldn't handle it
But I was still learning myself, too
That was a tough year
They expected me to be able to do more than I really could

That was my first year of teaching this course
So it was a learning experience for me, too

I’d like to incorporate much more writing
But I really never have had a lot of time in my general chemistry courses

I’m not an English teacher
I’m not a language arts teacher
I’m not a writing teacher
I’m not a reading teacher
However you want to look at it

To get more avenues to approach writing

Really helped me out
I do have to say that

I didn't get as much back-up as I would have liked to have had
Maybe it was me
Maybe I didn't ask as often as I probably could have
Or should have
I always felt like once I walked out of the door
I was on my own

Sometimes I didn't really know
Especially at the very beginning
I really didn't know how

I mean
I had written my own article
With a couple of revisions over the summer
But that was it

So, I would submit a lot of those original kids that I had
I'd just submit them directly to him
When I would get those back from him
I would read through his edits
So that I had an idea of what he was looking for

That way I had an idea
A better idea of what I should have done

We would do a little bit of editing here and there
But then we'd go on
And do something else
And do something else

I think they tried to help us with the editing process
But I just don't
Yes, I just don't think there was enough time

To get more examples
And being able to compare more with the editor,
What he was looking for
And what we were seeing

I think there were a lot of things
That were helpful
But there was a lot left off the other side
That kind of just left me hanging

I didn't have a way to pull it into my courses
Like I wanted to
I think if we just maybe had a little bit more support
That would have been good

Jessica - "Writing has never been a problem for me"

The first year I was really nervous about the project
I didn't know there were other people out there doing it

When I read the book
I was like this is exactly what I think
And I'm really glad that somebody else has already researched it
And written a book about it
Because I've been waiting for this project
Yes, otherwise I would have invented it myself

I felt like I did a lot of writing my first year
I did projects
I did writing

I really didn't feel like I could sign off on myself
For my own personal accountability
That I was giving the kids the skill they needed

I knew I was preparing them for high school
but I wasn't preparing them for the world
And so I was looking for it, yes

Writing has never been a problem for me
I'm a really strong writer myself
My instincts as a reader and writer are spot-on

My confidence in myself as a writer and reader
That helped

Making time for it was actually not a problem
I liked it to fill the gaps
It actually took some pressure off of me for content
So I always had something to plug in for flexibility

I didn't have to force something with chemistry
Like watch a dumb video that we didn't want to watch
I would no longer put fluff in

I'm a good writer myself
I was the kid who read the textbook in college
Always before the lecture and then reread it

So I guess I wasn't really afraid to read on any level
So yes, I was pretty scientifically literate
I could write
I could definitely write lab reports really well
I was good at research, too

I pretty much did everything they said in the book
Except I didn't spend much time on pitching last year
Which I am planning to do at the end of this week
And we did more on editing than what is in the book

I also looked at all the online resources
And pretty much made them my own
And made them assessable

Meeting other SciJourn teachers gave me a lot of validation
That the way I interpreted the book
Was the way that the researchers had interpreted the book
And other teachers thought that my stuff was usable
So it gave me a ton of validation

I would have kept the project
But it was just a lot cooler to meet other people
And to be more collaborative
So there was a sense of community, too

So I definitely would have kept it
But it was a little isolating

I really had to use my imagination
I felt like I was taking a risk for sure

How big the project is
When I say this took four and a half weeks
People are like, whoa I don't have four and a half weeks
Well, you actually do if you compact your curriculum a little bit

I think science teachers are just still fighting the writing
They're fighting it
Or they only want to grade on the content
Which this is really content but it's also process

I'm not going through and taking them down for spelling
But it needs to be readable
And we do, we edit for that
It needs to be understandable

I just think it's really intimidating
I went to a good high school
But I also went to a good college

I thought I would be middle of the road at best
Writing, reading or anything
I wasn't
I was the top

People thought I was, like, crazy genius
Because I could do those things
Well, all kids should be able to do those things going into college
And so technical writing
Or the rigor needs to happen in the science classroom
And be expected to

You write
You read in every class

It's like a cultural shift
It's a communication skill that I think should be really universal
And it's not
I have the skill set to teach that
So the kids in my class at least can have that opportunity

Appendix H: Project IRB Consent Form

Division of Teaching and Learning

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Informed Consent for Participation in Research Activities

Transformative Learning: An Exploration of Science Teachers' Changing Professional Identities, Knowledge, and Classroom Practices

Participant _____HSC Approval Number _____

Principal Investigator _____ PI's Phone Number _____

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1. You are invited to participate in a research study conducted by Michelle Phillips Whitacre and Dr. E. Wendy Saul at the University of Missouri-St. Louis. The purpose of this research is to examine the influence of the Science Literacy through Science Journalism Project (SciJourn) on participating science teachers. You are being asked to participate in this research because you were either a science teacher who participated in the SciJourn project or you were a researcher with the SciJourn team. We ask that you read this form and ask any questions you may have before agreeing to be in the research.
2. a) Your participation will involve
   - Participation in interviews
     Using a series of three interviews, you will be interviewed about your experiences with the SciJourn project. The location where the interviews will be conducted will be determined by the participants. These interviews will be audio recorded and transcribed for analysis by the researchers.
   - Follow-up interviews
     These interviews may be required after the three interview series to discuss additional questions that may come up during our analysis. The location where the interviews will be conducted will be determined by the participants. These interviews will be audio recorded and transcribed for analysis by the researchers.
   - Group interviews
     The researchers involved in the project will be interviewed as a group to gain insights into how the professional development was developed and the ways the project evolved over time. These interviews will take place at the University of

Missouri-St. Louis. These interviews will be audio recorded and transcribed for analysis by the researchers.

Approximately 20 participants may be involved in this research.

b) The amount of time involved in your participation will be a total of 2-10 hours.

3. There may be certain risks or discomforts to you associated with this research. They include the possibility that you may be uncomfortable with critiques or analysis of your insights.
4. There are no direct benefits for you participating in this study. However, your participation will contribute to the body of knowledge that explores how reform efforts and professional development experiences can be designed to successfully influence teachers.
5. Your participation is voluntary and you may choose not to participate in this research study or to withdraw your consent at any time. If you want to withdraw from the study, you can contact me at: michelle.phillips77@gmail.com or 773-573-3477. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw.
6. By agreeing to participate, you understand and agree that your data may be shared with other researchers and educators in the form of presentations and/or publications. In all cases, your identity will not be revealed. In rare instances, a researcher's study must undergo an audit or program evaluation by an oversight agency (such as the Office for Human Research Protection). That agency would be required to maintain the confidentiality of your data. In addition, all data will be stored on a password-protected computer and/or in a locked office.
7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Michelle Phillips Whitacre 773-573-3477 or Dr. E. Wendy Saul 314-516-4580. You may also ask questions or state concerns regarding your rights as a research participant to the Office of Research Administration, at 314-516-5897.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my participation in the research described above.

Participant's Signature Date	Participant's Printed Name
Signature of Investigator or Designee Date	Investigator/Designee Printed Name

Appendix I: SciJourn Article Writing Guidelines

A science news article is a tangible display of scientific literacy. A good SciJourner student article:

I. Has most or all of these elements: local, narrow, focused and presents a unique angle
   a. findings are meaningfully applied to personal or civic issues and
   b. readers' likely questions are anticipated and addressed.

II. Uses information from relevant, credible sources including the Internet and interviews. Successful authors…
   a. use Internet search terms and search engines effectively,
   b. privilege data from credible government and nonprofit sites and can justify the use of "other" sites, and
   c. locate and query experts and relevant stakeholders.

III. Is based on multiple, credible, attributed sources
   a. sources are relevant and reliable,
   b. stakeholders with varying expertise and experiences are consulted,
   c. sources are identified and basis of expertise is explained, and
   d. all assertions, numbers, details and opinions are attributed.

IV. Contextualizes information by
   a. telling why the information presented is important both from a scientific and societal viewpoint, and
   b. indicating which ideas are widely accepted and which are preliminary.

V. Is factually accurate and forefronts important information
   a. science connection is evident,
   b. difficult concepts are explained,
   c. precise language is employed,
   d. quantitative measures are given in correct and comparable units,
   e. information is up-to-date, and
   f. captions and graphics are checked for accuracy.

Appendix J: Science Article Filtering Instrument

Author _____ Topic _____ Date _____

To assess article quality, check one shape beside each characteristic. Use the key to determine level of quality.

Does the article being assessed contain any: (if unknown, check ◊)

1. stereotyping? YES Δ NO ◊
2. lies? YES Δ NO ◊
3. advertising? YES Δ NO ◊
4. PLAGIARISM? YES Δ NO ◊ NOTE: Reject article if one or more Δ checked.

The article being assessed contains:	COMPLETE (OR NEARLY COMPLETE) (check one) ◊	IN NEED OF IMPROVE-MENT (check one) □	ABSENT FROM ARTICLE (check one) ○
5. two or more sources of information that are credible and properly attributed.			
6. viewpoints from more than one perspective (when appropriate)			
7. a clear explanation of the science content which indicates a basic understanding by the author.			
8. attributions for **all** assertions (except those within the general knowledge of the audience).			
9. information that is relevant to readers.			
10. information that is factually accurate.			

KEY -

* If one or more Δ are checked, the article is immediately rejected.
* If one or more ○ are checked, the article is in need of significant revision.
* If one or more □ are checked, assessment depends upon ratio of ◊ and ○ checked.
* If every ◊ is checked (and NO Δ, □, ○ are checked), the article is ready for our managing editor with only minor additional revisions required.

Notes to author:

Evaluator _____