Surviving and Thriving as a New Science Teacher:

Exploring the Role of Comprehensive Online Induction

A DISSERTATION
SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF THE UNIVERSITY OF MINNESOTA
BY

Joel Dominic Donna

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

Gillian H. Roehrig and Fred N. Finley

June, 2009

Acknowledgements

Along my journey, many people have had a major impact on my life. Family, friends, mentors, colleagues, students, teachers and others from many phases of my life have shaped who I am and have ultimately influenced this work. Their love and support have helped make the journey through life both more meaningful and rewarding.

To my family: You have laid the foundation for who I am. My parents and grandparents have taught me the value of a well-rounded, humble life as well as the importance of treating others with respect. You have most importantly instilled a love for learning, teaching, citizenship, and science. I am thankful for my brother who, while we were growing up, was my partner—and sometimes instigator—in many un-authorized science experiments. He is a dear friend and trusted advisor for whom I am extremely grateful. To my extended family: I thank you all for your wisdom, love, thoughts, and prayers throughout this process.

To my 4-H and K12 school community: As a child and young adult I was able to 'learn by doing' by choosing 4-H projects that involved science and engineering (e.g., livestock, electricity, water quality, rocketry). All of these projects required that I teach others what I had learned. 4-H also prepared me to take on leadership roles. I am deeply grateful to the many 4-H'ers who have inspired me to 'make the best better.' In particular, I thank a 4-H friend, Ulrika Speckman for her gracious help editing this work. I am also grateful to my Jordan K12 teachers, extra-curricular advisors, and friends.

To my University of Wisconsin – River Falls Community: UW - River Falls provided me with a solid teacher education that launched my professional career as a science educator. I am grateful to Dr. Geoffrey Scheurman for his mentorship and sage wisdom throughout my life. I am grateful to my dear friends, who have kept me grounded and true to my core values through this graduate school experience.

To my Kasson-Mantorville Community: To the many students I've had the pleasure to learn from and with at Kasson-Mantorville during my time as a high-school science teacher: You have taught me so much about teaching, learning, and life. I thank you for your support. To my teaching colleagues, my brothers and sisters in arms: Your guidance, support, and love throughout the darker hours and brightest days provided me inspiration to grow as a teacher and as person.

To my University of Minnesota Community: To my committee: Dr. Aaron Doering, your passion for community and your faith in me as an instructor have helped me grow as a designer and teacher educator. Dr. Misty Sato, your mentorship and guidance particularly through the Teacher Support Partnership have helped expand my thinking on policy, leadership, and teacher professional development. Dr. Fred Finley, your help shaping my thinking and your words of encouragement and care throughout this process has meant such a great deal to me. Finally, to Dr. Gillian Roehrig, my primary advisor: Your faith and confidence in me to do this work has shaped who I am today as a scholar, teacher educator, professional developer, and policy advisor. I am so thankful for all you have done along this journey. I am also deeply thankful to Dr. Dee

Tedick, Jessie Eastman and other support staff, and to the Graduate School for their assistance, particularly with the Doctoral Dissertation Fellowship which has funded the writing of this work. I thank the many faculty and staff within the College of Education and Human Development who have acted as informal mentors towards my growth as an educator and scholar. To my graduate school friends: You have helped me to wrestle with concepts and ideas and make sense of this experience. I am thankful for your love and support.

To the Minnesota Department of Education (MDE) Community: I am thankful for the MDE for providing funding for the online induction program that provided the data for this thesis. Now, as an employee of MDE, I am grateful to my supervisors and colleagues for their support during the time of dissertation development. It is a pleasure to serve the great State of Minnesota with you.

Dedication

This work is dedicated to my family and friends within the many communities I've been blessed to be part of. This work is also dedicated to the STEM (Science, Technology, Engineering, and Mathematics) education communities, to those who serve our beginning teachers through mentorship, and to the beginning teachers themselves. Thank you all for your service as educators for our state, our country, and our world.

Abstract

The retention of beginning STEM (Science, Technology, Engineering, and Mathematics) educators is a topic of concern for researchers, policy makers, and other stakeholders. Comprehensive induction systems, that include content-specific mentoring, peer-based support, and other professional development activities, have been promoted as a solution to the retention crisis and as a way to help with the continued professional development of beginning teachers. Yet these content-specific induction programs are difficult to enact without the use of online environments. This dissertation explores data from an online induction program for beginning STEM educators through three studies.

The first study examines the educational, social, and technical affordances of an online induction environment for beginning STEM educators. This study first explores the designed affordances of the environment. Second, the study describes beginning teachers' perceived affordances of the online induction system. The study suggests that interaction with peers and experienced mentors, mediated through educational activities and online technology may be valuable in helping to meet the multifaceted goals of induction.

The second study explores how theory and practice influenced the iterative design of the induction program. In particular it looks at external barriers (e.g., limited time and energy, varied levels of technology access, lack of extrinsic rewards for participation) and internal barriers (e.g., beliefs about the value of supports, purposes of participation, sense of online community) that interfered with beginning teachers' engagement within this

online community of practice. This study also explores how the iterative design of this program was informed through this knowledge of barriers. Suggestions to help mitigate these barriers through careful program design and implementation are provided.

The final study examines the range of challenges that new science teachers face by examining the dialog between beginning teachers and content-specific mentors within the online induction program. This 'taxonomy of challenges' is then discussed in light of the role that content and context specific mentors can play in supporting new teachers' professional learning. The set of studies concludes with a discussion of implications that lead to an argument for re-envisioning the induction experience and the role of technology in supporting this new vision.

Table of Contents

Acknowledgements i

Dedication iv

Abstract v

Table of Contents vii

List of Tables x

List of Figures xi

Chapter 1: Introduction to Surviving and Thriving as a New Science Teacher: Exploring the Role of Comprehensive Online Induction 12

Background 12

Goals, Objectives, Designs, and Methods 14

Potential Significance 17

Chapter 2: 'Knowing I'm Not Alone': Exploring the Role of Affordances within an Online Induction Environment 18

Background 18

Theoretical Frame - Affordances 28

Focus of Study 32

Designed Affordances 33

Perceived Affordances 49

Discussion 60

Chapter 3: Engaging the Beginning STEM Educator within an Online Induction Community of Practice: Mitigating the Barriers through Design..................................... 68

Background 68

Prior Research 71

Theoretical Framework – First and Second Order Barriers 74

Methods 75

Version 1 (V.1) – (October 2006 – Feb 2007) 76

Version 2 (V.2) – (Feb 2007 – May 2007) 84

Summary of Barriers from V.1 and V.2 97

Discussion - Mitigating the Barriers 100

Implications for Current Design 104

Conclusion 110

Chapter 4: Taxonomy of Beginning Science Teacher Challenges 111

Background 111

Review of Relevant Literature 113

Research Questions 119

Context of Data 120

Sources of Data 122

Method of Data Analysis 123

Limitations of this study 128

Results.. 128

Summary of Challenges 165

Implications.. 169

Chapter 5: Toward a Vision of a Different Induction Experience for Beginning Science Teachers 175

Introduction.. 175

Curricular Engineers and Community-Based Repositories 183

Bibliography 188

Appendix... 201

Beginning Teacher Questionnaire.. 201

List of Tables

Table 1 *Summary of Designed Affordances* 48

Table 2 *Perceived Affordances* 61

Table 3 *"Which of the following have you sought support through?"* 83

Table 4 *"Choose the response that indicates your level of assistance needed"* 86

Table 5 *What is your preference for support?* 92

Table 6 *Blog Posts by Credit Level* 94

Table 7 *Summary of Barriers* 98

Table 8 *External Barriers Design Considerations* 106

Table 9 *Internal Barrier Design Considerations* 108

Table 10 *Veenman (1984) Perceived Problems of Beginning Teachers* 114

Table 11 *Literature on beginning secondary science teacher challenges* 118

Table 12 *Challenges related to Student Academics* 130

Table 13 *External Challenges* 133

Table 14 *Challenges related to teaching diverse learners* 135

Table 15 *Personal Beliefs, Attitudes, and Concerns* 137

Table 16 *Challenges Related to the Context of School or District* 141

Table 17 *Challenges Related to Classroom Management* 146

Table 18 *Challenges Related to Issues of General Pedagogical Knowledge* 152

Table 19 *Science Domain and Topic Level Pedagogical Content Knowledge* 159

List of Figures

Figure 1 *Taxonomy of Beginning Science Teacher Challenges*...................................... 167

Chapter 1: Introduction to Surviving and Thriving as a New Science Teacher: Exploring the Role of Comprehensive Online Induction

The "Robinson Crusoe Syndrome"

> I perceive a provisional model of how beginning teachers move to stability in their classroom performance. With just a little license, we can call the dominant motif the "Robinson Crusoe syndrome." For our beginner, like Crusoe, assaults the challenge of survival alone. As with Defoe's hero, the beginning teacher may find that prior experience supplies him with some alternatives for action, but his crucial learning comes from his personal errors; he fits together specific solutions and specific problems into some kind of whole and at times finds leeway for the expression of personal tastes. Working largely alone, he cannot make the specifics of his working knowledge base explicit, nor need he, as his victories are private. Having laboriously found techniques for mastering his immediate environment, he may, like his predecessor, prove ambivalent when the chance for a big change looms on the horizon. (Lortie, 1966, p. 59)

Background

The retention of highly effective teachers is a topic of concern among policy makers, professional organizations, teacher educators, and schools districts. Studies suggest that teachers leave the profession at rates of up to 50% within the first five years of their practice (Smith & Ingersoll, 2004). These high rates of attrition, combined with retirement of baby boomers, have caused shortages of teachers in some regions of the country. As it is generally agreed that teachers become more proficient as they progress throughout their career, students in districts with high levels of attrition suffer the most because they have larger numbers of beginning teachers. For science education, the need to retain qualified teachers is more acute due to a smaller available pool of these teachers (Ingersoll & Perda, 2006).

Induction programs can work to alleviate some aspects of job dissatisfaction by offering support during the tenuous years of beginning teachers' development. Induction programs also provide a critical bridge from teacher preparation to practice. These programs usually include mentorship from a seasoned veteran and vary in length of support, professional development activities, and collaboration with peers. However, it is a logistical and financial challenge for districts to provide comprehensive, subject-specific induction support, leaving many beginning teachers to face survival alone (Lortie, 1966) especially within high poverty schools (National Science Board, 2008).

Online induction may help to solve the problem of providing subject-specific professional development support. These programs can connect science teachers across a larger region with subject-specific mentors and peer groups where face-to-face communication may not be possible. Online induction can provide targeted professional development focused in praxis, curricular resources, and other forms of support that can supplement existing school-based induction programs. Hypothetically, these programs can help decrease isolation, increase the retention, and improve the practices of beginning science teachers.

While there are compelling arguments for the development of online induction programs for beginning science teachers, there is a lack of empirical knowledge surrounding such work. Missing from the knowledge base is an understanding of how interaction within an online induction community can be used to help meet the needs of beginning teachers and sustain professional growth. There is a need to understand the theory and practice of online induction programs for the science education community and the broader induction community.

Goals, Objectives, Designs, and Methods

This dissertation will examine an online induction program for beginning STEM (Science, Mathematics, Engineering, and Technology) teachers within a Midwestern state. In the 2006-2007 school years, this program served 65 beginning teachers, 35 of whom were in science. The goals of this program were to increase the retention of teachers and to improve beginning teacher performance. To combat job dissatisfaction caused by isolation and a lack of local supports, this program utilized both synchronous and asynchronous technologies to connect novice teachers with content-specific mentors and a community of their peers. Activities targeted toward the needs of novice teachers were also provided to help improve reflective, reform-based practices.

In the summer of 2007, Dr. Gillian Roehrig received a grant through the Minnesota Department of Education, funded by the National Governors' Association, to develop an online induction program for non-tenured STEM educators. Through guidance and collaboration with Dr. Roehrig, I served as program coordinator, led the programmatic and technical design team, constructed the pre-, mid-, and post-questionnaires, and led the face-to-face meetings and trainings. I also acted as a mentor within the program. I am very grateful to Dr. Roehrig for the opportunities that this experience has afforded.

This dissertation is a set of three studies that will analyze teacher data from the on-line induction program to help us better understand the complex nature of online induction programs. Due to the ability of the technology to capture online dialog, the data from this program offers us a unique window into conversations and reflections of beginning science teachers that can inform theory and practice in regards to the development and support of beginning science teachers.

Study One – What are the affordances of an online induction community of practice?

This first study examines the designed and perceived educational, social, and technical affordances (Kirschner, Strijbos, Kreijn, & Jelle Beers, 2004) of an online induction environment for beginning STEM educators. This study first describes the designed educational, social, and technical affordances of the professional development supports used within this program. The second part of the study uses qualitative methods to create a descriptive account of perceived affordances of the environment using open-ended responses from mid and post questionnaire data.

Study Two - What are the barriers toward engaging in an online induction community of practice?

This second study looks to inform both science education and the larger induction community as to how the interplay of theory and practice can be used to inform theory-driven designs of online induction programs. This qualitative study analyzes participation frequencies, qualitative and quantitative pre-, mid-, and post-survey data, and journals written by the lead designer to create a narrative on the iterative design of this program using an emerging paradigm of inquiry called design-based research (The Design-Based Research Collective, 2003). The data is analyzed through the lenses of first order barriers (external contextual issues) and second order barriers (internal beliefs) (Ertmer, 1999) that influence participation within this program.

Study Three - What are the challenges of learning to teach science as expressed through beginning teachers' dialog within an online community of practice?

This final study seeks to understand the range of challenges of learning to teach science as expressed by the beginning teachers through interaction within the induction program. To explore this question, the study uses qualitative methods to inductively analyze 165 chat room conversations between 24 beginning teachers and their mentors. This study also explores the role of content-specific support in mitigating challenges of beginning teachers toward improving their knowledge and practices.

Potential Significance

Through the analysis of this online induction model, we can help inform the theory and practice of beginning science teacher induction and potentially increase retention and improve the practice of beginning teachers. By better understanding beginning teacher needs and challenges we can inform the design of both pre-service and in-service science teacher education. This can lead to a seamless continuum of development from preparation to practice, assisted through technology-enhanced communities of practice. This work also adds to the knowledge of the larger induction community in regard to how technology can be used not only to make induction programs more efficient but also as a way to consider the ways these online communities of practice have transformative power beyond face-to-face induction.

Chapter 2: 'Knowing I'm Not Alone': Exploring the Role of Affordances within an Online Induction Environment

Background

Throughout the country, there have been numerous calls of concern about our nation's current and future supply of highly qualified STEM[1] (Science, Technology, Engineering, and Mathematics) teachers (Augustine, 2005). Within the next decade, there will be a need to replace a significant portion of the STEM teaching workforce due to the retirement of the baby boom generation (National Comission on Teaching and America's Future, 2009; Behrstock & Clifford, 2009). Estimates suggest that over one third of the teachers within the United States will retire within the next four years (National Commission on Teaching and America's Future, 2009). Some policy makers have advocated for alternative certification programs that ease entry into the profession to meet current and future demands for difficult to staff fields such as STEM education. In addition to alternative routes of entry, some (Augustine, 2005; Obama, 2009, April 27) have advocated for pre-service STEM recruitment programs that provide incentives, such as free tuition, to meet these demands.

[1] For the purposes of this paper, STEM refers to the separate domains of Science Education, Mathematics Education, and Technology Education of which Engineering Education is a part of, not an integrated view of STEM

However, some researchers and policy makers have reframed the problem as not an issue of supply, but as an issue of retention (NCTAF, 2009; Ingersoll & Preda, 2006). Across all domains of teaching, beginning educators leave their positions at rates of up to 50% within the first five years of their practice (Smith & Ingersoll, 2004). While mathematics and science teachers do not leave at significantly rates higher than their peers, the smaller available pool of candidates makes this problem more acute (Ingersoll & Preda, 2006). It is suggested that these high rates of attrition turnover due to job dissatisfaction have caused current shortages of qualified teachers in some regions of the country. Additionally, Ingersoll and Preda (2006) suggest that teacher education currently produces more math and science teachers than is required to replace future demands due to retirement, and that current levels of production would be sufficient if not for pre-retirement loss due to job dissatisfaction.

This pre-retirement attrition has caused a revolving door of teachers (Ingersoll, 2003) within many hard to staff schools, such as urban settings, creating an inequitable distribution of quality teachers. In addition, this high level of teacher turnover has created a high cost to schools, districts, and states. Nationally, it is estimated that teacher turnover accounts for 4.9 billion dollars in losses annually (Alliance for Excellent Education, 2005). It is argued that focusing our attention on retention of quality teachers instead of solely focusing on recruitment and alternative entry will help to alleviate current and future shortages of qualified STEM educators.

Programs for beginning teachers have been promoted as one potential solution to issues of retention by offering support in the early years of a teacher's development. [2] Yet some have argued that, "teacher retention alone is a necessary, but insufficient goal for induction programs" (Britton, 2009, p. 161). While it is critical, and perhaps morally just, that induction programs provide emotional support to help to retain beginning teachers, a focus solely on alleviation of immediate challenges these teachers face may miss critical opportunities for continued professional learning that improves teacher knowledge and practices (Achinstein & Athanases, 2006). Unfortunately, many programs within the United States have focused on the retention of beginning teachers, while other countries have focused on the improvement of beginning teacher quality (Britton, Paine, Pimm, & Raizen, 2003).

Within research and practice, professional development programs for beginning teachers are referred to as induction. Induction can be described as 1) a phase in a new teacher's development, usually from their first to third year of teaching and 2) a process of enculturation into a community of practice (Lave & Wenger, 1991) through a professional development program (Feiman-Nemser, 2001). Induction programs help beginning teachers transition from a 'student of teaching' to a 'teacher of students' (Smith

[2] Yet, induction programs are just one component of the retention issue. Factors related to attrition of beginning STEM teachers such as issues related to working conditions such as inadequate preparation time, class sizes, teacher input into decision making issues, or competitive salaries for STEM educators must also be attended to (Darling-Hammond & Sato, 2006; Ingersoll & Perda, 2006).

& Ingersoll , 2004, p. 683) and help them to enact their knowledge gained during preparation in new contexts (Feiman-Nemser, 2001) by providing technical, emotional, and instructional support. Elements of professional development within induction should be parallel to high-quality components within in-service professional programs for all educators. They should 1) be intensive, ongoing, and connected to practice, 2) focus on student learning and address the teaching of specific content, 3) build strong working relationships among teachers, and 4) align with school improvement priorities and goals (Darling-Hammond, Wei, Andree, Richardson, & Stelios, 2009). The primary goal of new teacher induction beyond continued professional development and increased retention should be the improvement of student learning.

Research suggests that teacher induction programs can be effective in supporting teacher development and helping to retain beginning teachers through multi-dimensional supports (Gold, 1996). In a review of the literature on new teacher induction Wang, Odell, and Schwill (2008) found that induction programs can provide technical support (e.g., school policies), emotional support, and instructional support (e.g., classroom management, resources and materials, improving instruction). Additional reviews of research on teacher induction programs (Wojnowski, Bellamy, & Cooke, 2003) suggest that the support they provide can improve teaching practices while helping to lower attrition rates.

Research on content-specific mentoring

Within STEM teacher induction it is important that these programs provide content and context specific support (Luft, 2003). Nationally it is reported that up to 90% of teachers receive some kind of induction support (Smith & Ingersoll, 2004), usually in the form of mentoring. Yet these numbers are lower for STEM areas. In a study of the induction supports for STEM teachers, the National Science Board (2008) found that 67% of science teachers and 71% of mathematics teachers participated in some form of induction support.

Although many states mandate at least some form of induction, such as mentoring, there are no states that currently mandate content-specific support (Koballa & Bradbury, 2009) leaving many beginning STEM educators without content-specific support. The National Science Board (2008) study found that 52% of mathematics teachers were matched with a mentor who was a mathematics teacher and 50% of science teachers were matched with another science teacher. Science teachers in schools with high minority enrollment (>45%) and high poverty (>50%) had much lower rates of content-specific mentoring, 40% and 35% respectively (National Science Board, 2008). Even if beginning STEM teachers are matched with a mentor who teaches the same discipline (e.g., science), their mentor may or may not be within the same domain and at the same grade level (e.g., a beginning high-school physics teacher matched with an experienced high-school physics teacher) within similar contexts (i.e., rural, urban, or suburban).

Reviews of research reveal the importance of matched, content and context specific mentors for beginning STEM teachers (Koballa & Bradbury, 2009) to help meet the unique subject specific needs of these beginning teachers (Davis, Petish, & Smithey, 2006). Research suggests that the pedagogical content knowledge or PCK (Grossman, 1990; Shulman, 1986) of beginning teachers is not nearly as developed as that of their more experienced colleagues (Gold, 1996). For example, beginning teachers may struggle to transform particular content into meaningful experiences for their individual students by selecting appropriate pedagogies, assessments, and examples that match particular content with particular contexts. Research within science education supports that having a well-prepared mentor who teaches in similar contexts (e.g., students, subjects, grades) may not only be a powerful combatant in science teacher attrition, it may help beginning teachers work toward meeting the goals of reform-based science instruction through the development of subject specific pedagogical content knowledge (Luft, 2003; Wojnowski, Bellamy, & Cooke, 2003). However, it is a logistical and financial challenge for many districts to provide such subject specific induction support, especially in rural schools, as these teachers may be the only teacher of their kind.

Systemic, comprehensive induction for STEM educators

Yet, content-specific mentoring alone for beginning STEM teachers is not enough to improve practice and stem attrition. Smith and Ingersol's (2004) national study found that teachers who received basic levels of induction support, which included a mentor and supportive communication with an administrator, left the profession at rates similar to those without mentoring. As induction supports increase through activities such as cohort groups that participate in content-specific professional development, the retention increases. Research on induction programs echo the idea that having a subject specific mentor alone is not enough, as it is logistically and emotionally difficult for mentors to be the sole of support for beginning teacher development (Britton & Raizen, 2003) due to the varied needs of beginning teachers. In addition, research suggests that mentors sometimes reinforce traditional practices (Feiman-Nemser, 2001) instead of promoting reform-based practices.

Induction programs for STEM educators must shift toward comprehensive, systematic designs (Britton & Raizen, 2003) that move beyond traditional one-to-one mentoring toward collaborative, community-based approaches that support individual STEM teacher learning. These comprehensive, systemic approaches to induction through a suite of sustained professional development activities may help to challenge the long standing educator culture of isolation (Lortie, 2002) that adversely affects beginning teacher job satisfaction and professional growth. Beyond content-specific and context specific mentors, peers who teach the same subject in similar contexts can be an invaluable resource as they provide opportunities to lament, pose questions, and to collaboratively work through issues of enactment (Huling-Austin, 1992).

Research on science education induction programs suggests that content-specific professional development is important for beginning science teacher development (Luft, Roehrig, & Patterson, 2003). In a large scale study of science teacher induction, Roehrig and Luft (2006) determined that well-designed induction programs that address the beliefs and needs of teachers can impact teacher practices through professional development activities. However, beyond these studies there has been little research on science specific induction programs (Britton, 2009; Davis, Petish, & Smithey, 2006).

Framing comprehensive, systemic induction around communities of practice

The knowledge base surrounding communities of practice is helpful for framing the research and development of systematic, comprehensive induction programs. Research suggests that communities of practice are essential in enacting reform initiatives (Barab, Barnett, & Squire, 2002; Barab et al., 2003; Schlager & Fusco, 2003) and are necessary for professional growth (Hammerness, Darling-Hammond, & Bransford, 2005).

To provide induction into a content-specific community of practice, such as science education, Wang, Odell, and Schwill (2008) suggest that induction programs must be modeled on a vision of quality science instruction guided by content and teaching standards such as those described in the National Science Education Standards (1996). This perspective suggests that induction supports should be based on a conception of teaching expertise that is content-specific, multi-dimensional (Bransford, Darling-Hammond, & LePage, 2005; Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee, 2002). This shifts the focus of teaching expertise from one based on depth of subject matter knowledge towards pedagogical content knowledge (Abell, 2007). By enculturating beginning teachers into each of the STEM communities of practice through content-specific induction, we can begin to bridge content-specific teacher preparation to professional practice (Feiman-Nemser, 2001: Kahle & Kronebusch, 2003).

Communities of practice can be leveraged to develop induction programs that bring together stakeholders concerned with science, mathematics, and technology education to share their common knowledge, beliefs, and practices with beginning teachers. Interaction within the community can help these beginning teachers to enact their knowledge in their new context through authentic, professional development activities that help them to both thrive and survive. It thus becomes the moral responsibility of the entire community of practice to induct beginning teachers into the profession through content-specific support. Yet it is a logistical and financial challenge to gather these communities of practice members within regular face-to-face settings to provide such content-specific induction for beginning teachers.

The role of online technology in supporting online induction communities of practice

Online technologies can be leveraged to create technology-supported communities of practice (Fulton, Yoon, & Lee, 2005) that can help support local induction efforts to form a more systemic comprehensive system for a district, region, or state (Schlager & Fusco, 2003). Online technologies can connect STEM teachers with subject specific mentors and peers where face-to-face communication may not be financially or logistically possible (Gentry, Denton, & Kurz, 2008). These online induction programs can also be used to provide targeted professional development and resources for teachers of specific subjects and practices. Policy reports (Behrstock & Clifford, 2009) suggest that new generations of teachers may benefit from professional development that utilizes emerging technologies with which these teachers may be already familiar. In many cases, online induction programs can be used to supplement existing school based induction programs by providing additional levels of support that are targeted to the needs of STEM teachers.

Research on online induction systems

Online induction programs may be one of the only ways to provide a true comprehensive system of induction; however there are limited studies that explore the role technology can play in supporting new teacher development. Extensive online searches and literature reviews on technology-supported mentoring (see Gentry et al. 2008) and online teacher induction revealed seven peer reviewed studies (Babinski, Jones, & DeWert, 2001; Babinski, & Jones, 2003; Brady & Schuck, 2005; DeWert, Gareis & Nussbaum-Beach, 2007; Romano, 2008; Shuck, 2003; Merseth, 1991). All studies used one or two forms of support activities, primarily online forums/discussion boards. On-demand support in these discussion boards was provided by peers and/or experienced teachers. None of these studies included content-specific support through the assignment of content specific mentors nor additional professional development supports.

The New Teacher Center's large scale online induction program, eMSS (Electronic Mentoring for Science Success) is an established example of a large scale, subject specific online induction program. A book chapter on the structure of the program (Jaffe, Moir, Swanson, & Wheeler, 2006), and conference presentations (Grimberg, 2006, McAlleer, 2006, and Taylor & Mike, 2006) generally lend support to the program goals for the development of pedagogical knowledge and pedagogical content knowledge as well as the development of reflective problem solvers. Additionally a dissertation by Bice (2006) found that interaction within a diversity module within the eMSS program helped beginning teachers adapt their classroom practices to create a more respectful learning environment. Additional large scale induction programs, such NCTAF's Teachers Learning in Networked Communities (National Commission on Teaching and America's Future, 2009) and eMSS, are scaling up to serve teachers nationwide.

There is a need to understand online teacher induction systems that are moving toward a vision of comprehensive induction that includes attention to both content and context specific needs of beginning teachers through systemic professional development activities. What is needed is additional research that can help designers develop quality online induction programs and explore the ways in which online induction systems afford teacher learning and increased job satisfaction.

Theoretical Frame - Affordances

It is important to research online induction environments from a perspective that accounts not only for the educational activities and the social interactions between mentors and peers, but also for the role that technology plays in supporting the activities and the goals of the induction program. Kirschner, Strijbos, Kreijn, and Jelle-Beers

(2004) suggest that many online collaborative environments have been designed without attention to the educational, social, and technical characteristics of the environment and user interactions with these characteristics. Kirschner et al. suggest that designers often assume because the technology within an online environment allows for interaction, that pedagogies and social interactions that work within face-to-face environments should transfer to online environments. As a result of this inattention, Kirschner et al. suggest that “what often results is disgruntled or disappointed students and instructors, motivation that is quickly extinguished, poorly used environments, wasted time and money, and showcase environments that are often not much more than computer assisted page turning” (p. 48).

A deeper understanding of the relationships between the participants and their online environment is required; that is the educational, social, and technical affordances of the environment that help to meet the goals of the program. Affordances are the perceived and actual properties of an environment that invite “opportunities for action” (Kirschner et al., p 49) between the individual and the environment. An affordance must be perceivable and useable by the individual toward an end goal. A common example of an affordance is a door handle (Gaver, 1991). If the door has a vertical handle with a place for us to grasp, this affords us a door that we must pull to open to walk through. A door with a horizontal push bar affords us a door we can push to walk through. A door to a child’s play house provides a different interaction experience for an adult than it does for the child. That is, individuals interact with their environment in different ways.

Within online learning environments, such as online induction programs, there are always interactions between the participants and the educational, social, and technical affordances of the environment (Kirschner et al., 2004). Educational affordances are the relationships between the learner and the environment that mitigate if and how learning will take place. The educational affordances must be able to support the individual learning needs of the participant as they arise. Social affordance components within an environment allow for and encourage interaction and collaborative learning. In an online learning environment, we must also concern ourselves with technical affordances. Kirshner et al, (2004) describe technical affordances as technology that “mediates the social and educational contexts such that their properties induce and invite specific learning behaviors” (p. 50).

Participant interactions are influenced by many factors such as expectations and prior experiences. The educational, social, and technical affordances within an online learning environment must fulfill the intentions of the participant in a meaningful way. When a user perceives an affordance, the environment must encourage and guide them toward action. In an online environment, the technology must provide a high degree of usability for this mediation to occur.

In online learning environments, the educational, social, and technical affordances must work in concert to meet the educational goals of the program. A designer must select the pedagogy to meet the goals of the project. Doering, Miller, & Veletsianos (2008) suggest that social components of the design must “enrich the chosen pedagogy by providing engaging opportunities that encourage the social dynamics and collaborative interactions which exist habitually in traditional face-to-face learning" (p. 8). In addition, Doering et al. suggest that the technology within the environment "must not only allow for these social interactions to emerge, but ultimately thrive by providing an effective and efficient structure that satisfies users as they accomplish tasks and collaborate with peers in the environment." (p. 9). The technical characteristics of the environment must be explored as they shape social interactions and the pedagogies themselves in ways that are unique and vastly different from face-to-face settings (Kirschner, Strijbos, Kreijn, & Jelle Beers, 2004). If proper attention is not paid to the affordances of the environment, there may be "minimal learning, interaction, and collaboration" (Doering, Miller, & Veletsianos, 2008, p. 12).

In the case of online induction environments, designers must attend to educational, social, and technical affordances. Designers should use reflective and active pedagogies to teach reform-based knowledge, pedagogies, and habits of mind (educational), through interactions with experienced community members and other beginning peers (social), while using online technologies to deliver the supports in interactive, efficient, and collaborative ways that attend to the unique interaction experiences afforded through the technology. In addition, focusing on affordances within induction systems may allow researchers to explore how technology affords social and educational interactions that may hold transformative power beyond traditional induction supports.

Focus of Study

This study examines the affordances of a yearlong online induction program for beginning STEM teachers in a Midwestern state. It will first describe the designed or intended affordances. Second, this study will describe examples of beginning teachers' perceived affordances of the online induction environment to understand what the environment affords, especially as it relates to the role of technology in supporting beginning teacher induction. The second part of this study will also pay attention to the role that social affordances play within this online community of practice toward exploring how groups of novice and experienced peers can work toward meeting the immediate and individual needs of beginning teachers while helping to induct the beginning teachers into the profession.

Research within communities of practice provides a useful frame for this study. When research is situated within a community of practice, the community can become the driver of the research by identifying pragmatic questions that are of interest in sustaining and transforming the community. In this way the community becomes the beneficiary of the research as well as the medium by which the research is conducted. In this study, this research garners information from key members of this online community of practice, the beginning teachers, to inform both research and practice as it relates to online teacher induction.

In this study, community will be used two ways. Community in this study is used to describe the interaction of the participants within the environment toward the formation of an online community of practice. Technology-supported communities of practice are described as “a persistent, sustained, [socio-technical] network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise” (Barab, Barnett, & Squire, 2002). Community is also used to describe the larger science and math education communities of practice, each of which has their own set of shared, yet evolving, beliefs, practices, and knowledge (Lave & Wenger, 1991). The intention of this online induction environment was to be a smaller community of practice that would be nested within the larger science and math communities of practice.

Designed Affordances

This section will first provide an overview of the online STEM induction program and will then describe the intended or designed affordances of environment. The goals of this online induction program were to improve and enhance teacher knowledge and practices while increasing the retention of the participating STEM teachers. To increase retention of these teachers, supports were designed to improve job satisfaction by providing on-demand assistance that would meet the immediate needs of the beginning teachers. In this program supports were not characterized as a support that provides only psychological or technical support, but as a support or scaffold toward learning the habits, practices, and beliefs of the larger community of practice. To enhance teacher knowledge and practices while increasing job satisfaction, the supports had the following sub goals: to increase pedagogical content knowledge (Shulman, 1986) through content-specific support, to increase the enactment and refinement of reform-based practices and curriculum, to improve reflective practices in order to accelerate the development of these beginning teachers, and to decrease the isolation of these teachers through community-based interaction and collaborative learning.

Within this induction program, the participants were to engage with several online supports throughout the course of the six month program. This was a blended online induction program as there were two face-to-face meetings in which the participants learned about the supports, built community, and participated in professional development seminars. The online supports were developed within a learning management system called Moodle. These online supports included bi-weekly mentor/beginning teacher conversations, professional development inquiries or PDI's, monthly small learning community discussions, and reflective journals. These supports had different foci but were designed to complement each-other to meet the goals of improved practice and retention.

The following sections will provide a brief explanation of each online support, the goals of the support, and the designed or intended educational, social, and technical affordances. The section will conclude with a brief discussion of the overall designed affordances of the environment.[3]

[3] It should be noted that this design went through two iterations throughout the course of the program. Except where noted, the designed affordances refer to the second iteration of the design, not the initial. For a discussion of the design iterations as well as the 'broken' affordances and efforts to improve usability, please see 'Barriers' chapter

Mentor/Beginning Teacher Conversation Designed Affordances

The primary support within this online induction program was the 'mentor/beginning teacher conversation' support in which beginning teachers interacted with a content-specific mentor (e.g., a high school chemistry teacher was matched with a beginning high school chemistry teacher). During the first half of the program, the beginning teachers and mentors met four times a month; during the second half of the program the mentors and beginning teachers met twice a month. The mentors and beginning teachers met either in an online chat or held a sustained discussion within an online forum. The goals of the mentor/beginning teacher conversation support were to meet the immediate needs of the beginning teachers, while simultaneously helping the teacher to refine his or her repertoire of reform-based practices through content-specific conversations, to continue the development of pedagogical content knowledge to help improve the learning environment of their classrooms, and to help navigate local politics among other goals.

Conversation protocols were the primary designed educational affordance for the Mentor/Beginning Teacher Chat support. These protocol-driven conversations helped to focus the conversation around the relationships between the instruction, the content being learned, and the learners, instead of focusing solely on isolated challenges. In addition, professional teaching standards were used to facilitate goal setting that could help guide the conversations between the mentor and the beginning teacher.

Interaction with an experienced, content-specific mentor within the mentor/beginning teacher support was to afford social interaction to meet the above goals of this support. Interaction with this mentor was to afford a sense of trust as well as access to a deep content, pedagogical, and pedagogical content knowledge base from which the beginning teacher could draw from. These mentors were matched with their beginning teachers to ensure that there was similar content, age of students, and similar contexts (i.e., rural, suburban, or urban) if possible. Mentors were selected for their experience with classroom instruction and mentoring of other beginning teachers.

Beyond a deep pedagogical content knowledge situated in a similar context, these mentors also were prepared to work with beginning teachers in an online environment to have a bifocal knowledge base (Achinstein & Athanases, 2006) to afford interaction to facilitated teacher learning. The mentors engaged in professional development around topics such as the characteristics of beginning teachers, how to use mentoring protocols, and the unique aspects of mentoring within an online environment.

Mentors also provided several other social affordances. The mentors afforded an outside perspective since they had distance from the local politics of the beginning teacher's school. This could afford a safe place to discuss unique concerns and challenges. Within the conversation, the mentors were free to provide different kinds of support depending upon the situation; they were to provide technical, psychological, and other support as warranted. Mentors could not only use the conversation to provide the appropriate levels of support (i.e., instructive to facilitative), they could use multiple sources of data gained through interactions with the beginning teacher in other supports to guide and adapt additional support in order to meet the individual needs of the beginning teacher. In essence, the mentors could provide additional educational supports and affordances as determined through interaction with the beginning teacher.[4]

The technical affordances of the mentor/beginning teacher conversations were designed to work with social and educational affordances. The beginning teachers had a choice of communication tools that offered them flexibility in terms of medium and time. Beginning teachers and their mentors could choose from synchronous and asynchronous supports. Each tool provided its own set of technical affordances. The synchronous, real time text based chat and instant message tools most closely resembled auditory or face-to-face forms of conversation. These supports allowed for the discussion of issues that were of immediate interest to the beginning teacher and allowed for real-time exploration of the problem with mentors. They also had the choice of an asynchronous interaction in a private forum. These supports were designed to provide deeper, reflective thinking and to provide scheduling flexibility to access the system, as the mentor and beginning teacher did not have to be online at the same time. It is suggested that online forums may provide deeper levels of reflection than face-to-face settings due to opportunities for extended interaction time (Hawkes & Romiszowski, 2001). Forums further afforded the

[4] This is not to say there were not social affordances for mentors - mentors were also to engage in co-learning in which the beginning teachers were empowered to help the mentors improve their knowledge and practices as well.

capability of attachments of student work samples, curricular resources, and other digital files as needed. When a new post was made to the thread, both the mentor and the beginning teacher received an email notifying them of a new response to encourage continued dialog. Within both the asynchronous and synchronous components, the learning management system provided a record of these conversations for the beginning teachers and mentors to review for later reflection.

Professional Development Investigation Designed Affordances

The second support was a professional development investigation or PDI. The beginning teachers were to participate in two PDIs that were nearly three months in length. The first PDI focused on how to plan instruction. The second PDI provided a choice of topics on pedagogical strategies such as inquiry, non-linguistic representation, vocabulary, cooperative learning, skills, and processes. The goal of the PDI support was to continue to help the beginning teacher to refine his or her repertoire of reform-based practices through the development and implementation of content-specific curriculum that applied and refined knowledge from the selected topic. These activities stressed the improvement of reflective practices through action research components in which the teachers modified their enacted curriculum based on analysis of student work.

The PDI had several educational affordances that were designed to help the beginning teacher meet the goals of the PDI activity. The beginning teachers and their mentors were provided with checklists that listed the activities and specific outcomes, instructions, and time-lines. The first PDI focused on how to plan instruction for student learning. For the second PDI, the beginning teachers were provided a choice of pedagogical strategies to investigate and implement that afforded a choice of topic that was most aligned with their professional learning goals. Each PDI followed a scaffolded sequence of activities in which they were to reflect, explore, apply, implement, analyze, and refine.

In the ‘reflect stage’, the beginning teachers reflected on their current practices and beliefs with regard to the selected topic. In the ‘explore stage’, they explored theory and research on which the pedagogical strategies were based. The participants then ‘applied’ the general pedagogical strategies to teach a particular topic within their content area. They then ‘implemented’ the lesson and ‘analyzed’ their implementation through analysis of uploaded samples of student work. Finally, the beginning teachers ‘refined’ the curriculum and uploaded materials into the programs’ wiki for other participants use.

The social affordances were designed to work with the educational affordances of the PDI activity. Mentors, peers, and a PDI facilitator worked with the beginning teacher throughout the PDI activity by providing feedback to each other at each step.[5] The PDI facilitator helped to draw connections between comments and acted as a guide for the beginning teacher and mentor.

The mentor’s role in the PDI activity was to provide feedback during every stage of the PDI. The mentors assisted with curriculum development and implementation of the instructional strategies by helping the beginning teacher put these general pedagogical

[5] Note: The PDI’s were done with peers who may or may not have been in their content area.

strategies into a content-specific and context specific unit of instruction. For example, a beginning chemistry teacher participating in the inquiry PDI worked with his or her mentor to implement inquiry based pedagogies into the instruction around the topic of chemical reaction rates.

Participants also engaged in community building activities within the PDI. The role of community building was to create a social environment in which the beginning teachers could feel safe to express successes and challenges related to reform-based instructional strategies. In addition, the PDI's had embedded community affordance devices such as user-generated avatars (i.e., photos, icons, and other images) that appeared on every posting that linked directly to their user profiles.

The PDI activity included several designed technical affordances. First, due to the asynchronous nature of the forum-based PDI, the reflection could take place in a textual and multi-media form. Face-to-face or synchronous reflective conversations can be difficult due to the often rapid sequence of exchanges. But in this textual environment, the reflection could take place at a slower pace and at the convenience of the participants. For example, reflections were made and posted immediately after instruction instead of at a predetermined meeting time. In addition, multimedia capabilities that allowed the beginning teachers to upload student work samples and draft lesson plans were utilized to provide a place for the PDI group to explore others' approaches to implementation and to share their reflections on implementation. Finally, there was a site wiki that allowed beginning teachers to share a record of their PDI work with the other beginning teachers with the hopes that they could take the lessons and adapt them for their own use.

Small Learning Community Designed Affordances

The Small Learning Community conversations or SLC conversations were small groups of ten to fifteen beginning teachers and their mentors who taught similar aged students and content (e.g., the chemistry teacher group, the physics teacher group, the high school math teacher group, middle school life science teacher group). This support had two main purposes. The space allowed shared questions and concerns to a larger group of peers. Some of the beginning teachers taught multiple domains and needed support beyond what their mentors could provide. During the first half of the program, the beginning teachers and mentors were free to post to their private discussion boards and were to meet in a chat room once a month to hold an SLC 'chat'.[6]

The second purpose was to have the SLC engage in conversations around content-specific case discussions called Dilemmas. During the second half of the program the SLC beginning teachers and their mentors were to engage in a monthly discussion around these cases in either a chat room or a forum. Through the exploration of the dilemmas, the teachers were to examine assumptions of their own practice and were to develop strategies to help manage similar dilemmas of their own (Lampert, 1985). The cases were written from the perspective of a beginning teacher asking for help from his or her

[6] There were also open forums around topics such as classroom management, community notices, and others in which any member of the community could post.

peers. The cases were SLC specific; that is that the case narrative was tailored to the individual SLCs. This tailoring was designed to provide a similar context to that of the SLC that would potentially provide relevance. In addition, the purpose of the dilemmas discussions was to provide a space for rich, content-specific discussion around topics of common concern to beginning teachers such as student engagement, student assessment, and other topics. For example, a case about classroom management was to be discussed from the perspective of high school physics instruction within the physics SLC. Some SLC groups, such as the middle school and high school life science SLC, received dilemmas that addressed teaching controversial content such as the theory of evolution. While dilemmas were provided, the beginning teachers were free to create and share their own cases instead.

The SLC dilemmas invited the participants to engage in the activity through designed educational affordances. The content-specific relevance of the case invited the beginning teacher to engage with a relevant dilemma. They were then asked to provide advice to the beginning teacher in the story while simultaneously reflecting on why they provided this advice and how this related to their vision of practice. Also, they were asked to explore the inherent tensions and potential conflicts in their advice to trouble the notion that there are perfect solutions and to reinforce the complexity of decision making (Lampert, 1985). Finally they were asked to hypothetically apply their advice to their own instruction to explore how this may relate to their own practice and how to enhance their own practices. [7]

The social affordances of the SLC dilemmas were designed to elicit the sharing and exploration of responses from the group through a facilitated discussion. First, the beginning teachers were to explore this problem individually by positing a response. They were then to respond to other beginning teachers' posts. The SLC facilitator's role was to push the conversation deeper by drawing out similarities between responses as well as differences, asking for clarification, and posing larger questions. After a period of time, the mentors would then engage in the conversation by responding to the dilemma and the responses of the beginning teachers. The beginning teachers could also respond to the mentors while comparing the thinking of their more experienced colleagues to their own.

Similar to the PDI discussion, careful attention was paid to developing a sense of community through icebreaker activities during face-to-face meetings and within the online environment to afford a greater comfort and depth in exploration of the dilemma. Through sharing stories via the dilemma discussion or in the open discussion areas, it was hoped that other beginning teachers could empathize and see that they were not alone with the challenges that they faced. Similar social affordance devices, such as avatars and community profiles were also a component of the SLC conversations and also were implemented to afford a greater sense of community.

[7] Special thanks to the eMSS program for sharing their 'dilemmas' to be used within this program.

The technical affordances within the SLC conversation were similar to those of the PDI. The SLC groups had a choice of either a large synchronous chat room or an asynchronous group discussion board. Many of the SLC groups opted to use the asynchronous threaded discussion for discussion of the dilemmas to alleviate the issues related to scheduling a common time to engage in a group discussion. This option was also suggested by the designers as it allowed for an easier way to meet the above structure of beginning teacher discussion followed by mentor discussion. The asynchronous nature of the forums also allowed for a slower form of reflective discussion than would take place within the chat rooms.

Designed Affordances of the Reflective Journal Activity

The final support was a reflective journal activity. In this reflective journal, the beginning teachers were to write one reflective post per month. The goals of this support were to help the beginning teacher explore personal a challenge or concern. Through writing, it was hoped that the beginning teacher could refine their thinking around the concern, challenge their own assumptions surrounding the concern, and improve their practice.

The reflective journal activity was designed to promote interaction through designed educational affordances. Beginning teachers were to write about whatever they chose through this free writing exercise. This space of reflection was provided so they could have a written and perhaps more coherent record of their thoughts. This activity was also designed to provide a time for reflection within a beginning teacher's busy day.

The social affordances within the reflective journal support provided a venue for the beginning teacher to share and explore others' challenges, questions, and reflections on their experience as a beginning teacher privately to the community. The support was designed to provide a safe space to vent, explore, challenge as well as to think about their practice in unique ways. This social support also was intended to help break down isolation.[8]

The technical affordances of reflective journal activity provided the beginning teacher with options as to how public to make their reflections. A post could be made private to only the journal space or it could be shared to the larger community. The journal activity also provided a system of organization through tagging in which the beginning teacher could use keywords called 'tags' that represented the content in their post. Tags for posts could provide a unique way for beginning teachers to explore themes through a tag cloud. Similar to the affordances provided by the forums within the mentor/beginning teacher chats, PDI, and SLC activities, the asynchronous nature of the reflective journal area provided a chance for the beginning teacher to write on demand. This also afforded additional interaction in which the beginning teacher could return to older posts to examine changes in the topics that were of importance earlier and now.

Several educational, social, and technical affordances were designed into this online induction environment that cut across all supports (see Table 1). The educational

[8] Face-to-face interaction provided additional educational and social opportunities beyond online interaction

affordance supports were designed to attend to individual, immediate needs through choice. Concurrently, the supports were designed to afford interaction that promoted pedagogical content knowledge through the development and implementation of reform-based curriculum and the refinement and enactment of other reform-based practices. In addition, these activities all were designed as opportunities for continued refinement of reflective practices. Across these supports, the intention of the design was not to be a set of disparate education supports with separate goals, but educational supports that were complementary.

The social affordances of this online environment were designed to complement the educational activities. Every support was designed to have interaction with a peer; either a more experienced mentor or a fellow beginning teacher with a similar content background. These social interactions were designed to provide opportunities to learn from, to learn with, and to provide support from the community. Through these interactions, it was intended that the community could help provide outside perspectives. Social affordance devices, such as avatars and online profiles also helped to foster a sense of online identity and to grow the strength of the online community. Facilitators within the environment help to encourage discourse in many of the supports.

The technical affordances allowed for social interactions within the educational supports. This online environment afforded flexibility in terms of when the participants could access the supports as well as flexibility in the medium by which those supports are accessed. The online environment was designed to afford a record of reflection and interaction that could be used by the beginning teacher to reflect on his or her prior interactions as well as to provide multiple sources of data for the mentors to help guide the tailored support of their selected beginning teacher. External notifications through email and RSS feeds also encouraged sustained interaction. Without these designed technical affordances supporting the flexibility of access and without the peer interaction through the designed social affordances, the pedagogical affordances of the environment would have provided little support to these beginning teachers. In addition, the technical affordances within the environment invited content-specific support through peer interaction.

Table 1 *Summary of Designed Affordances*

Educational	Social	Technical
a) Variety of supports to meet immediate needs (technical, psychological, content) b) Activities that stress implementation of reform-based practices within content and context specific environments c) Activities that stress the improvement of reflective practices and exploration of assumptions d) Complementary activities	a) Connection with peers (mentors and other BT) with similar context and content b) Outside perspectives from community c) Challenging assumptions and beliefs about practice through interaction d) Community development through technologies that promote sustained engagement (e.g. avatars, online profiles)	a) Flexibility of access time – on demand b) Flexibility of mode of communication c) Saved discussions and artifacts d) External notification of posting through RSS readers and Email e) Ongoing design and redesign to ensure usability

Perceived Affordances

This section of the study provides specific examples of perceived educational, social, and technical affordances of this online induction environment from the perspective of the beginning teachers. Illustrating perceived affordances from the perspective of individual participants will help better understand the design of online induction programs. This section will also include a secondary focus on the role that social and technical affordances of the online induction program play in supporting beginning teacher growth toward meeting the multifaceted goals of the program. Understanding the social affordances can help us to explore the role that both experienced and novice peers, who teach similar content in similar contexts, may play in supporting beginning teacher growth within induction programs. Additionally, understanding technical affordances will help to explore the unique role that technology-supported online induction environments may play in complementing and supporting face-to-face induction programs.

The sources of data for this study included mid- and post-questionnaire data (n=45,46) that asked open-ended questions about the various support activities, the technologies used to support the program, and questions about the program overall[9] as well as final reflective papers (n = 12) from beginning teachers who completed this paper to receive graduate credit.

[9] See Appendix for sample questionnaire

This exploratory study uses qualitative methods of research (Miles & Huberman, 1994) through an inductive approach to describe the landscape of perceived educational, social, and technical affordances. The conglomerate set of responses with relevant open-ended questions was first read. The open-ended responses that alluded to affordances, that is interactions between the beginning teacher and the environment, were first selected and then coded as affordances as operationalized above. Second, these affordances were then grouped into educational, social, and technical affordance classifications.[10] The responses were then grouped into sub-categories below the educational, social, and technical groupings based on the uniqueness, not the frequency, of the response to provide a landscape of affordance interactions that can be explored through further research. Again, affordances are unique personal interactions with one's environment and differ from user to user based on prior knowledge and expectations. The following sections highlight the perceived educational, social, and technical affordances.

Educational Affordances

Educational activities afford a choice of professional development foci based on the individual needs of the teacher. A choice of activities, particularly within the professional development inquiries, afforded opportunities to meet the specific needs of beginning teachers. For example one beginning teacher states that "I liked that I was in a

[10] It should be noted, and perhaps expected, that some of the statements could not be classified as purely educational, social, and technical affordances due to the complementary nature of the affordances.

specific group that focused on the topic of inquiry since this was the area of my teaching I wanted to improve the most." Choices, not only in the PDI but within the mentor/beginning teacher conversations, may afford opportunities for continuous improvement through self directed learning.

Educational structures afford ease of use through supports that are scaffolded and structured. This environment afforded carefully scaffolded and sequenced educational activities. One beginning teacher was pleased with the choice of inquiry for their PDI, as "it was easy to use it in my classroom, and the timeline and length of activities were good. It was very easy to keep up and participate." Carefully designing activities are critical in online environments as there are fewer opportunities for adjustment and for monitoring student confusion with instructions. Facilitators and mentors provide a critical role in helping navigate the activities to provide a greater ease of use.

Educational activities afford participation in professional development that directly impacts classroom instruction. The educational supports afforded opportunities for learning that directly impacted the day-to-day activities of the beginning teachers. One beginning teacher writes that "the program helped me with new ideas and strategies that I could bring back to my classroom, and help me connect with others for ideas and support. Students benefited by way of me having a better idea of what I wanted to be doing in the class, and being able to more efficiently / effectively implement the ideas." Another beginning teacher notes a positive relationship with the environment when they state that "I appreciated the way the program enabled me to grow quickly as a teacher." Like all professional development, induction should be job-embedded (Darling-Hammmond & Richardson, 2009) to provide relevance, a space for implementation of refined pedagogical knowledge, and a space for reflection on implementation.

Educational supports afford interaction that addresses pedagogical knowledge, beliefs, and practice within the context of practice. Through this online induction program, activities afforded opportunities to improve and refine pedagogical knowledge within the context of practice. One beginning teacher felt that the PDI activities "had a positive impact on me and my students. I would not have tried the different inquiry lessons if I had not been in the [induction] program. My students would have missed out on the experimental inquiry lessons." Another states that "I feel much more comfortable with experimental inquiry and feel like I am more attentive to student needs." These comments speak to the educational affordances within the site that were designed to provide activities embedded within the classroom practices, to improve pedagogical knowledge, and to challenge teacher beliefs and prior knowledge about these practices. These comments may also suggest that this online induction program may have helped improve the refinement of reform-based practices such as inquiry based pedagogies for these participants.

Educational activities afford a space and a time for reflection on practice. This program afforded multiple opportunities for personal reflection within the context of structured and unstructured activities. One beginning teacher states that, "I found it interesting to reflect on my teaching. It helps me think through my teaching and it helps me remember where I came from and how I am different now." Throughout the course of day-to-day activities, it may be difficult for a beginning teacher to have both a safe space and time for reflection. Online induction systems may help to provide opportunities to help teachers make sense of their practices through written reflection.

Social Affordances

Content-specific mentors afford differentiated support based on beginning teacher needs. Beginning teacher interaction with content-specific mentors within educational supports afforded access to multiple supports based on individual needs. One beginning teacher expresses the variety of supports that their mentor provided them when they state "I do not think I would still be teaching if I did not have my weekly chats with my mentor…. I learn new activities to do, classroom management strategies, group discussion ideas, encouragement, reminders, and an infinite amount of wisdom that gets me back at the school the next day." In a final questionnaire this same beginning teacher explores the importance of content-specific interaction in meeting their needs. They state that "It was reassuring to know that every week I had someone in my field, in my content area, and outside my school to keep me going." As cited within prior research (Luft, Roehrig, & Patterson, 2002), content-specific mentors can help facilitate the continued development of pedagogical content knowledge.

Social interactions afford multiple perspectives on practice from the community. Interactions with peers afforded multiple perspectives on practice. One beginning teacher writes that "I enjoyed reading the text and the contributions from SLC members. It was great to see all the ways people incorporated experimental inquiry into their classes!" Another beginning teacher states that "it was awesome to get feedback from such a group of different teachers that all approach situations a little differently. What works for one person doesn't always work for the next, so it was nice to get many perspectives." This suggests that seeing varied enactment of pedagogical knowledge in unique contexts within a content-specific community may help these beginning teachers understand and value the role of pedagogical content knowledge within their own practice.

Social interaction affords a safe place to explore ideas with others. This environment afforded a safe space for beginning teachers to explore challenges they faced within their classroom. One beginning teacher writes that they valued "having a place that I could journal my thoughts that I could share with others, but [I] knew there was a limit on who was reading it." The mentor/beginning teacher conversation support also provided a safe place as well as a distant perspective on individual classroom dilemmas for some participants. A beginning teacher speaks of this safety when they write that "it is also nice that we are at different schools so I can vent to an unbiased source about my students and building issues. My mentor provides a safe, respectful, and encouraging atmosphere." This social affordance is supported by the technical affordances of the environment that provide a secure, password protected environment that connects content-specific peers from a distance.

Social interaction affords a quick response to immediate challenges from the community. This online environment afforded a rapid response to beginning teachers' questions from community members. One beginning teacher writes that "it was very nice to have a resource and to have a place to ask a specific question and get quick responses from many people." Having a group of content-specific peers which one can access on demand through an online environment may be a valuable support to provide content-specific support beyond that of a mentor.

Social interaction affords a stance of career long continuous improvement through sharing and exploration of peer concerns. This online induction environment's social affordances, within the educational activities in which other beginning teachers interacted, afforded peer-to-peer interaction that may have helped promote a stance of continuous improvement. One beginning teacher writes that through this program they "did not feel like I was completely isolated, even though I don't have a counterpart at this school. I gained assurance that everyone has their struggles, and it is ok to just keep working for improvement, even if there are weak spots." This comment shows that interactions with other beginning teachers along with interactions with more experienced peers can help to instill a vision of continuous improvement within a community of practice. Another beginning teacher states that "the program helped me to see that many things I was experiencing were common among first-year teachers. Seeing that mentors were still enjoying teaching after many years helped me to feel optimistic about my future as a teacher." The beginning teacher and experienced teacher interactions for this participant may have helped reframe dilemmas of practice that are common for all teachers and reinforced the belief that a long career as a STEM teacher can be a joyful one.

Social interaction affords content area support and decreased isolation through interaction with content peers. Beyond sharing similar challenges, this online environment afforded a place for peer-based support to help mitigate the challenges they faced. One beginning teacher writes that "I really enjoyed the [online induction] program because of the support and sense of community that I had all year long. Instead of feeling like an outsider because I was a rookie, I felt like I had a place to turn to where people in situations similar to mine would come together. It was a breath of fresh air to have friends to turn to outside of my school and within my content area to share stories, fears, and activities." Another expresses the importance of shared struggles and group support in mitigating these challenges when they state that "I gained so much as a person and as a teacher with the connections I made with my mentor and some of the other teachers. The exchange of ideas and suggestions was crucial my first year. Not only did all of the various interactions keep me motivated, they also kept me intrigued in teaching and reminded me I was not alone! Knowing that there were people out there who supported me and who were dealing with similar situations made this year less lonely and more meaningful." This comment suggests a meaningful interaction and an emotional connection to the community. These statements together suggest that interaction with peers can provide not only assistance toward mitigating the challenges they face, but can also work to decrease isolation that may help to instill the importance of community and may improve job satisfaction. The role of peer-based support mediated through technology, especially with other beginning peers who teach similar content, should be explored in further research.

Technical Affordances

Technology afforded access to the community through limited legitimate participation. Online learning environments afford participation in ways that may be different from face-to-face environments. Within this online induction environment it was a challenge to sustain full participation for some beginning teachers. However, some of these beginning teachers read the posts from others but did not necessarily engage further. One beginning teacher states that "unfortunately I got behind in the [other] activities and felt it was too much to get ahead or back in the swing of things. I did read the posts by the other people in my group and viewed this as a great sense of community that I wish I had participated in more." Within an online induction community of practice, participation may not always take the form of active posting, it can be limited legitimate participation or LLP (Lave & Wenger, 1991) which may be a valuable interaction in itself for beginning teachers (Jaffe, Moir, Swanson, & Wheeler, 2006).

Technology afforded access to repositories of community developed curricular resources that can be used within the classroom. This online induction platform afforded access to community developed curriculum. Technology such as wikis and the content-specific forums helped to support the community member needs for quality instructional materials. One beginning teacher states that “I think the help I got from the forums and lessons from the wiki were great. It was really nice to have as a resource when looking for ideas and activities.” Online induction environments that contain curricular repositories can work with educational and social supports not only to create a curriculum for the individual teacher, but then to share it with the larger community. These online repositories can act as a way to transmit a shared set of beliefs and practices in the form of lessons that can be taken and modified to meet the contextual needs of the beginning teacher and serve as an on-demand support.[11]

S*ynchronous and asynchronous technologies afford the ability to connect beginning teachers with mentors and other via distances*. Within this online environment, technology afforded the connections of beginning teachers to their mentors within the educational and social supports. A beginning teacher states that “I appreciated the use of online chatting - talking in "real" time was very valuable and appreciated, especially considering my mentor was in [a rural part of the state]”. Without online technologies, it is a difficult logistical and financial challenge to connect beginning teachers to content-specific peers.

[11] Other research within this dissertation, particularly the challenges chapter, supports the strong desire for beginning teachers to have access to community developed curriculum and learning object

Technology affords flexibility of online tools for access time as well as for purpose. Beginning teachers felt that technology afforded connection with mentors that was flexible. One beginning teacher notes that “being able to connect with my mentor via [instant message or IM] was a nice tool to have. Sending these IMs as emails when one of us wasn't on was a great way to help us connect as well.” Another beginning teacher states that they “liked the forums - they allowed us to communicate with one another, but we didn't have to all be online at the same time, which was nice considering everyone's busy schedule.” Flexibility of access provides choices that can help meet the time management needs of the busy schedules of teachers.

Technology affords access to prior reflections to help gauge growth. This online environment afforded access to prior reflection within the different supports. One beginning teacher states that “it was nice to be able to look back and see what was going on as the semester progressed (and my thoughts on it).” Another beginning teacher states that “the blogs forced me to reflect on my teaching and also allowed me to look back on previous entries and see where I was at different points in the year.” This comment captures the importance of matching the technology tool with the educational and social supports to ensure an environment that provides affordances toward meeting the goals of one’s program.

Discussion

How the affordances work together to meet the goals of the environment

In summary, we see that participants experienced a variety of educational, social, and technical affordances. As we examine the set of affordances below (Table 2), it may appear as a disparate set of affordance interactions. However, as this is a community-based online induction environment in which peers and mentors interacted through educational activities, we begin to see how these educational, social, and technical affordances interact.

Table 2 *Perceived Affordances*

Educational	Social	Technical
a) Choice of PD activities targeted to individual needs of teacher b) Ease of use through supports that are scaffolded and structured c) Professional development activities that are relevant and directly influences classroom instruction d) Professional development activities that address pedagogical knowledge, beliefs, and practice within the context of practice	a) Content-specific mentoring for support based in individual teacher needs b) Multiple perspectives on enactment from the community c) A secure place to explore challenges with peers d) Quick response to immediate challenges from the community e) Interaction with community focused on continuous improvement	a) Access to the community through limited legitimate participation b) Access to community developed curricular resources that can be used within the classroom c) Ability to connect via distances with synchronous technologies d) Flexibility of online tools for access time as well as for purpose e) Access to prior reflections to provide broader perspective and to gauge growth

e) A space and a time for reflection on practice	f) Meaningful interaction with peers for support and decreased isolation

For example, social affordances, such as the provision of multiple perspectives from the community of practice, cannot exist without the solicitation of these perspectives from within the relevant educational supports, through the SLC dilemmas and the PDI support. It is also difficult to imagine that these social affordances could exist without the technical characteristics of the environment that provided a safe interaction space as well as tools that enabled meaningful and flexible interaction with novice and experienced peers. The set of affordances suggests that interaction with peers and experienced mentors, mediated through educational activities and online technology may be valuable in helping to meet the multifaceted goals of induction. However, if there is a breakdown in any of the educational, social, and technical components of the environment, the environment cannot support the goals of continued growth and retention.

The role of technology in supporting induction into the larger community of practice

Technology that enabled the creation of this online induction community of practice can also help to enable connections to the larger community of practice. For many districts and schools, providing content-specific support is difficult logistically and/or financially, or may even be impossible as these beginning teachers may be the only teachers of their kind. Although many states mandate induction, there are no states that currently mandate content-specific support (Koballa & Bradbury, 2009). Technology can play a role in pooling resources to build smaller communities of practice supported by larger communities of practice such as STEM teacher professional organizations.

Furthermore, technology can play a role in connecting teacher educators, professional development leaders, local and national teacher organizations, and in the case of eMSS (Jaffe, Moir, Swanson, & Wheeler, 2006), content-specific professionals such as scientists, to work together to help induct these beginning teachers into the larger community of practice in ways that help transform all components (Barab, MaKinster, & Scheckler, 2003).

In addition, technology enhanced communities of practice, in which there is a blend of face-to-face and online activities, as in the case of this program, may provide the best of both worlds. Face-to-face interactions can build a sense of community and can help prepare participants to use the tools and learn the affordances of the supports that can help prepare a better online learning experience. Future research could explore how technology enhanced communities of practice may work to decrease the isolation and improve the practices of the mentors, which may lead to their continued retention of the mentors themselves.

Technology enhanced induction environments may also afford interactions and teacher learning that move beyond face-to-face induction programs through affordances such as the flexibility of access, storage of reflection, and use of secure environments. As new Web 2.0 technologies emerge, such as collaborative document creation, online video analysis, and web conferencing, we must use them in a responsible and careful manner to help supplement and extend face-to-face induction efforts, not only to try to replicate face-to-face environments. For example, in the 3rd generation of this online induction program, collaborative document technologies were used for mentor/beginning teacher chat logs, lesson plan construction and annotation, and formative assessment activities based on professional teaching standards. However, the use of emerging technologies for the sake of using technologies, without careful attention to pedagogies, social structures, and end goals may result in a fragmented and perhaps unusable environment (Doering, Miller, & Veletsianos, 2008; Kirschner, Strijbos, Kreijn, & Jelle Beers, 2004).

The role of beginning peers within an online community of practice

Finally, there is great promise in leveraging peers toward supporting the goals of content-specific induction. As noted above, both beginning and experienced peers can afforded interaction that broke down isolation and improved practices through a shared sense of struggle. This finding supports research that has found that beginning teachers value online interactions that afford the ability to share information with other beginning teachers (Brady & Schuck, 2005) and that this interaction may decrease teacher isolation (DeWert, Babinski, & Jones, 2003). However, this research additionally suggests that content-specific peers, interacting within a content-specific, online induction environment, play an important role in attending to issues of isolation related to being the only teacher of their kind within their school and can support each-others' content-specific challenges.

During the process of induction, more experienced members of the community (mentors) help bring the nascent members (beginning teachers) into the larger community through the exploration of commonly shared practices and beliefs. While these beginning members are being inducted into the community they can also work to transform the beliefs and practices of the more experienced community members (Lave & Wenger, 1991). However, this study suggests that induction is not only an act between the mentor and the beginning teacher, but induction may be enabled through support from other beginning peers.

This study suggests that within an induction context, the nascent community members can simultaneously commit to learn and shape the beliefs, practices, and habits of the larger community while committing to mentor other beginning teachers. As teaching is multifaceted and multidimensional, we may expect that beginning teachers are at various levels of expertise across various dimensions of teaching. It may be possible that peer mentoring, in which the strengths of one teacher can support the areas of weakness of another and vice versa, may prove to be a valuable induction support. The impacts of interactions between beginning teachers, within a community of practice, must be further explored.

Online supported communities of practice that attend to the educational, social, and technical characteristics of the environment can form communities in which participants learn from and with each other, meld “theory and practice, doing and reflection, the individual and community, in a manner that transforms all components” (Barab et al., 2002). Online induction programs that have a strong community of practice supported by education and technical supports may have the potential to help assuage issues of retention related to isolation. More importantly, online induction systems can help to foster continued professional development of beginning STEM educators towards improving student learning within the STEM domains.

Chapter 3: Engaging the Beginning STEM Educator within an Online Induction Community of Practice: Mitigating the Barriers through Design

Background

The beginning educator retention is a topic of concern among stakeholder groups such as policy makers, professional organizations, teacher educators, and schools districts. Studies suggest that teachers leave the profession at rates of up to 50% within the first five years of their practice (Ingersoll, 2001). These high rates of attrition, combined with retirement of baby boomers, have caused shortages of teachers in many regions of the country. As it is generally agreed that teachers become more proficient as they progress throughout their career, students in districts with high levels of attrition, a so-called 'revolving door' of beginning teachers (Ingersoll, 2001), may suffer the most as they have larger numbers of beginning teachers. For STEM (Science, Technology, Engineering, and Mathematics) education the need to retain qualified teachers is more acute (Ingersoll & Perda, 2006; Smith & Ingersoll, 2004) due to the smaller available pool of teachers.

Induction programs can work to alleviate some aspects of job dissatisfaction by offering support during the first years of beginning teachers' professional practice. Yet a focus solely on retention misses the critical opportunity to provide a bridge from teacher preparation to practice through sustained professional development (Feiman-Nemser, 2001) through teacher induction programs. While induction programs usually include mentorship from a seasoned veteran, they vary significantly in length of support, professional development activities, and collaboration with peers (Ingersoll, 2001). Although many schools have mentoring programs, not all beginning science teachers are matched with a content-specific mentor who teaches the same STEM discipline. Finding these subject-matched mentors is challenging, particularly in small charter and rural schools as these teachers may be the only teacher of their kind (e.g., the only Physics teacher, the only Calculus teacher). Research within science teacher induction suggests that having a well-prepared mentor who teaches science in similar contexts (e.g., students, subjects, grades) may be one of the more powerful combatants of science teacher attrition (Luft, 2003) and may impact teaching knowledge and practices (Luft, Roehrig, & Patterson, 2002). However, it is a logistical and financial challenge for districts to provide subject specific induction support through content-specific mentors, content-specific professional development activities for beginning teachers, and interaction with other beginning peers who teach similar content.

Online induction programs may help to solve the problem of providing subject specific induction. These programs can connect science teachers across a larger region with subject specific mentors where face-to-face communication may not be possible (Fulton, Yoon, & Lee, 2005). Online induction programs can also connect teachers to a larger community that can be used to provide targeted professional development focused in praxis, resources for their specific subjects, and induction into the larger science education community. These programs can supplement existing school-based induction programs by providing additional levels of support targeted to the needs of science teachers. Hypothetically, these programs can help decrease isolation, increase retention, and improve the practices of beginning science teachers.

While there are compelling arguments for the development of online induction programs for beginning STEM teachers, there is a lack of empirical knowledge surrounding such work. Studies suggests that face-to-face, discipline-specific induction within science education may impact both beginning teacher beliefs and practices (Luft, Roehrig, & Patterson, 2002; Roehrig & Luft, 2006), but there are few other studies in this area and none deal specifically with online induction. Missing from the knowledge base is an understanding of how interaction within an online induction community can be used to help meet these challenges and sustain professional growth.

There have been substantial efforts contributing toward developing and expanding online induction programs such as the National Science Teachers Association eMSS (e Mentoring for student success) (Jaffe, Moir, Swanson, & Wheeler, 2006), National Commissions on Teaching and America's future TLINK (Teachers Linked In Networked Communities) program (National Commission on Teaching and America's Future, 2009), and Illinois statewide New Teacher Collaborative (Wilkins & Clift, 2007). However, there is no published, peer-reviewed research on online induction systems beyond studies that focus mentoring within induction (Gentry, Denton, & Kurz, 2008) and descriptive papers (Herrington, Herrington, Kervin, & Ferry, 2006; Jaffe , Moir, Swanson, & Wheeler, 2006). In addition, research on in-service teacher professional development suggests that there are substantial challenges involved in developing and sustaining online communities of practice (Barab, MaKinster, & Scheckler, 2003; Schlager & Fusco, 2003). Therefore, in the face of substantial investments of time and money, it is important to explore the theory and practice surrounding the work of online induction systems, and in particular, to understand the potential barriers toward engagement within an online community of practice for the content-specific induction. These understandings may help to promote more efficient, better designed programs that provide sustained interaction which helps beginning teachers thrive and survive. This study will explore the barriers toward engagement within an online, comprehensive induction program.

Prior Research

While there are no studies that specifically address the barriers toward engagement within a content-specific online induction system for beginning teachers, the limited literature on barriers toward engagement within face-to-face mentoring programs, online professional development for experienced teachers, and general online mentoring programs for both beginning and experienced teachers, can provide a starting place for investigating barriers related to content-specific induction programs.

A review of research on science teacher mentoring (Koballa & Bradbury, 2009), suggests that differing conceptions between a mentor and a beginning teacher on the purposes of mentoring can lead to very different outcomes. For example, "partners who understand the role of mentor as local guide or provider of teaching materials will realize different mentoring outcomes than partners who view the role of mentor as seeker of knowledge about science teaching and learning" (p. 176). Additionally, in a review of research on induction and mentoring, Gold (1996), found that beginning teachers may not feel they need mentoring as they begin to feel they are more proficient with their instruction in areas such as classroom management. As this literature focuses on mentoring not necessarily within an induction framework, there is a gap in knowledge regarding the barriers toward engagement in a more comprehensive, systemic induction programs.

Research on online professional development can inform us about potential barriers toward professional development for induction, particularly with regard to the work around communities of practice. Online communities of practice are "a persistent, sustained, [socio-technical] network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history and experiences focused on a common practice and/or mutual enterprise" (Barab, MaKinster, & Scheckler, 2003, p. 55). In the case of online induction communities of practice, this smaller community of practice would represent the knowledge, beliefs, and other components of the individual domain and larger community (i.e., the science education community).

Prior research on the sustainability of an online professional development community of practice (Barab, MaKinster, & Scheckler, 2003) suggests that there can be tension inherent to the design of the program, between the goals of the reform movements and meeting the immediate needs of the teachers that community serves. The tension occurs between the limitations of time and other constraints that many educators have throughout the day and the time that is required to engage in meaningful work that may change their practices. Research suggests teachers want to explore questions such as 'what am I going to teach tomorrow?', 'how will I deal with this disruptive student?' and 'how do I teach this topic to my students?' before engaging in additional professional development activities (Barab, MaKinster, & Scheckler, 2003). Similarly, Hawkes & Romiszowski (2001) found that usage and depth of in-service teacher reflection depended upon the teachers' beliefs about the amount of time that they had to participate. However, these studies do not account for beginning teachers' unique interaction with online induction environments.

Finally, research on online mentoring programs for both beginning and in-service teachers can help to inform this work. Gentry, Denton, and Kurz's (2008) review of 14 in-service (both beginning and experienced) teacher mentoring programs found that teachers' engagement with technology-based mentoring was mediated by the following: 1) the availability of hardware and internet connections at schools and at home, 2) the time available to participate in the program, 3) the individual teacher's comfort with technology, 4) the amount of training included in the program, and 5) the teachers' beliefs about the value of the interaction with the mentors. However, it should be noted that only six of these studies focused on beginning teacher interaction. Of these six programs under investigation, three were solely peer-based mentoring and the others were combinations of peer-based and mentor interaction. None of these programs had content-specific foci. In addition, these programs would be classified as an on-demand mentoring support system designed to meet teachers' immediate needs. The mentors were not assigned to particular beginning teachers. These programs' visions differ from a focus on comprehensive induction systems that envision content-specific professional development support that attends to beginning teachers' individual needs while providing space for ongoing, sustained professional development with multiple supports.

Theoretical Framework – First and Second Order Barriers

This study examines the obstacles that hindered meaningful and sustained participation within an online induction program for beginning STEM educators in a Midwestern state. This study uses the lenses of first and second order barriers (Brickner, 1995; Ertmer, 1999) to explore these obstacles. First order barriers (Brickner, 1995) are obstacles that are external or extrinsic to a beginning teacher. These barriers are beyond the control of the teacher, can be related to resources, access, support, and time. Ertmer (1999) states that "having to deal with numerous first-order barriers simultaneously may frustrate teachers who feel pressured to overcome every barrier" (p. 5) before engaging in an educational innovation related to technology.

Second order barriers (Brickner, 1995), are intrinsic obstacles, related to teacher beliefs such as fears, insecurities, and perceptions that are contrary to the goals of the innovation. First order barriers may be mitigated through provision time and training. However, Ertmer (1999) suggests that second-order barriers are more difficult to overcome due to personal nature of these beliefs. Understanding both perceived first and second order barriers that beginning teachers face may be helpful in the design and implementation of future online-induction programs.

Methods

This study uses an emerging paradigm of study called design based research. Design based research (The Design-Based Research Collective, 2003) seeks to modify learning theories through designing, implementing, and refining theory-based interventions in naturalistic, educational environments. This theory-driven, applied research uses methods from various paradigms to study interventions and produce new theories of teaching and learning (The Design-Based Research Collective, 2003). This study will analyze data through the lenses of first order barriers (external contextual issues) and second order barriers (internal beliefs) that influenced participation within this program (Brickner, 1995; Ertmer, 1999) to better understand how these challenges interplay with the design and redesign of this online community of practice. It will provide a chronological narrative to discuss the iterative design of this program and how the evolving knowledge of barriers helped to shape the design.

To explore the barriers within this program, this qualitative study uses multiple sources of data to explore the participant's first and second order barriers. The primary source of data comes from two questionnaires that contained multiple open-ended questions. These questionnaires were given at the midpoint of the program (n = 45) and at the conclusion of the program (n = 47). Each set of data was analyzed using qualitative methods of research (Miles & Huberman, 1994) through an inductive approach to determine the first and second order barriers toward sustained and meaningful participation. The open-ended questions were first read and coded as barriers. Subsequent analysis grouped these codes into first and second order barriers based on barriers as operationalized above (Brickner, 1995; Ertmer, 1999). Additional data such as participation frequencies from the learning management system, designer reflective journals, participant emails, and qualitative questionnaire data were used to triangulate the findings as well as to provide a framework for the narrative on the design and redesign of this pilot induction program. The following sections will describe each version of the program and the barriers that emerged throughout each iteration. [12]

Version 1 (V.1) – (October 2006 – Feb 2007)

V.1 - Design Goals

This online induction program was designed to provide emotional, technical, and instructional support for beginning secondary math, science, career and technical education teachers within a Midwestern state. The goals of this online induction program were to improve and enhance content-specific teacher knowledge and practices while increasing the retention of the participating STEM teachers. Within this program, supports were not characterized as a vehicle to provide only psychological or technical support, but as a support or scaffold toward learning the habits, practices, and beliefs of the larger community of practice through sustained, content-specific professional

[12] For a more detailed explanation, please see the Affordances study

development. This program used Moodle, an online, open-source learning management system, as a platform to provide both synchronous and asynchronous forms of communication for the professional development supports. The following describes the components of Version 1 (V.1) design of this program[13]:

Mentor-Beginning Teacher Chat: This was a private area for conversations between mentors and beginning teachers. Each beginning teacher was assigned a mentor who taught a similar content area and if possible, taught in a similar context (e.g., rural, suburban, urban setting). The beginning teachers were required to meet at least weekly with their mentor in either a private synchronous chat room or via a sustained conversation within an asynchronous private discussion board. The goals of the mentor/beginning teacher conversation support were to meet the immediate needs of the beginning teachers, while simultaneously helping the teacher to refine their repertoire of reform-based practices (Feiman-Nemser, 2001). Interaction through these content-specific conversations would help to continue the development of pedagogical content knowledge (Grossman, 1990; Shulman, 1986) to help improve the learning environment of their classrooms, and to help the beginning teachers with additional aspects of practice (e.g., local politics) as needed.

Small Learning Communities: The beginning teachers were grouped with 5-7 other beginning teachers and their mentors who together formed a content-specific small learning community or SLC. The SLCs were organized by subject matter and grade level

[13] For a more detailed explanation see the Affordances chapter

to support beginning teachers by providing access to resources for use in the classroom as well as space to engage in conversations. The beginning teachers could ask questions and post concerns in this area via a private group asynchronous discussion board. [14] Additionally, the beginning teachers and their mentors were required to meet synchronously with their SLC in a chat room on at least a monthly basis.

Professional Development Investigations: The original design required beginning teachers to participate in three sustained professional development activities called PDIs. The first PDI was designed to improve lesson planning through an 8-week learning cycle. This was done by helping the beginning teachers focus on student learning and student work by critically examining their own teaching in relation to their beliefs and commitments, and develop the skills of data collection, analysis and reflection. The beginning teachers were to work through this cycle with the guidance of their mentors as well as members of their SLC.

Reflective Journals (Blogs): Beginning teachers were to complete weekly blog entries designed to help them reflect on their practices and to serve as a way for mentors to better understand the needs of their beginning teachers. They also provided a tool for beginning teachers to reflect back on their growth over the year. Beginning teachers were to post once per week.

---

[14] There were also additional forums for the larger community to provide announcements, to build community, and to discuss other issues outside of the private mentor and SLC conversations

V.1 - Implementation

For this program, 58 beginning STEM teachers were recruited. The group comprised 38 science, 13 mathematics, and 7 Technology Education and Family and Consumer Science teachers. Of these 58 participants, 12 sought course credit by completing online assignments. 13 sought credit in conjunction with a monthly face-to-face course for beginning science teachers[15]. The teachers were evenly distributed among rural, suburban, and urban districts. Although a majority of the beginning teachers were in traditional middle and high school settings, 12 beginning teachers were in alternative or charter schools. Many of the participants were first (n = 22) and second year teachers (n = 19), yet there were a number that had three or more years of experience (n = 11).

After recruitment of beginning teachers and mentors, the mentor teachers attended a face-to-face meeting to learn about the goals of the online induction program, the activities within the program, and the technology used to support the activities. In addition, they discussed the challenges new teachers may face, ways to provide different kinds of support, and how to engage in mentoring in an online environment.

In October, 2006, the mentors and the beginning teachers were brought together for an initial face-to-face meeting. Each attendee was provided with financial support for a substitute teacher and mileage. The goals of the meeting were to provide an overview of the program, to build community and trust among the mentors, beginning teachers and

[15] These participants were not required to complete the PDI activities

their small learning communities, to provide background information on common characteristics of beginning teachers practice, and to introduce the technologies employed in this program. Unfortunately, not all of the beginning teachers were able to attend this meeting.

After the initial month of the program, participation within the program began to wane. Although monthly mentor logs showed that there was substantial contact between mentors and beginning teachers, engagement with the rest of the activities, such as the SLC chats, PDI activities, and the Blogs, did not meet the design teams overall program expectations. There was also attrition in the early stages of the program, primarily by the beginning teachers who never attended the initial face-to-face meeting. In addition, the design team[16] became overwhelmed by the challenge of providing technical support for over 100 users and facilitation of conversation in the 12 SLC groups and PDI investigations.

In January, the midpoint of the eight month long program, the design team decided that a program redesign was necessary at the mid-point of the program. In preparation for the redesign, a questionnaire with 80 closed and open-ended qualitative questions was sent to the mentor-beginning teacher pairs to determine the barriers toward engagement. 45 of the 51 beginning teachers (81% response rate) responded to the questionnaire.

[16] The design team consisted of the author and Gillian Roehrig

V1. External Barriers toward Engagement

Although beginning teachers were generally satisfied with the program, several barriers toward engagement were identified. The primary external barrier toward engagement was time. The beginning teachers were overwhelmed with the time requirements of planning instruction, grading, and setting up laboratories and they felt that there was not enough time to fully engage within the program. When queried about barriers toward engagement with the PDI, 13 of the beginning teachers who did not complete all of the PDI activities cited some form of time constraint keeping them from engaging with the activity. When asked about the difficulties they had in engaging with the PDI, one participant noted a list of items such as "I am too busy to add to my load. I have three preps, teach night school, coach the knowledge bowl team…I am active parent/wife, plus am in the process of buying a house." Other similar comments suggested that the PDI was a lower priority due to limitations of time.

For the SLC and Mentor/Beginning Teacher Chat activities, it was a challenge for the groups to arrange a consistent time to meet each month when they were all available. This form of synchronous chat, while allowing for immediate response and feedback that is most similar to face-to-face conversation, does present a challenge for beginning teachers who are already overwhelmed with the demands on their time and find that they must find an hour of time in to which they can dedicate to the program.

The technology used to support this community also acted as a barrier to engagement for some of the participants. For those who did not attend the face-to-face training, they found interaction with the site challenging. During the face-to-face training, mentors, and other beginning teachers explored the site and learned strategies to help navigate through the environment. Those who did not attend had to rely on less interactive video and text based trainings.

Firefox, an open source web browser, is the preferred browser for Moodle. While it is a free program, it did cause issues with some participants as it added an extra step in accessing the site. For those who wished to participate from their school (31%) because they lacked internet access at home, this often meant that a technical administrator would have to come install this software on the computer, adding another task for an already busy teacher.

Many of the participants engaged at home either due to time or school technology limitations. However, for those who accessed the program from home with dial-up connectivity there were technical issues with the chat room application used for Mentor/Beginning Teacher Chats and SLC Chats. Some commented that the chat room was slow and often crashed.[17]

These technical issues, coupled with the time barriers, may explain why many beginning teachers preferred to email their mentor instead of using the chat room or site forum as a place to seek support (see Table 3). Some switched to phone calls or in-person visits to communicate with their mentor. One participant commented “I don’t like the chat format…I’d rather talk on the phone, because communication is more natural and

[17] Later Moodle upgrades helped to resolve some technical issues

you get more talking in less time." While email can be used to engage in the mentor/beginning teacher conversation support, it does draw participants away from the other community and the collaborative supports within the program, creating a less comprehensive induction experience that relies on one-on-one mentoring.

Table 3 "Which of the following have you sought support through?"

	Yes	Count	No	Count
Mentor/BT Chat Room Meetings	81.4%	(35)	18.6%	(8)
Mentor/BT Email	79.5%	(35)	20.5%	(9)
Mentor/BT Forum Messages	51.2%	(22)	48.8%	(21)
SLC Chat Room Meetings	45.5%	(20)	54.5%	(24)
SLC Forum Messages	39.5%	(17)	60.5%	(26)
Other Mentor Communication (F2F, phone, etc)	22.0%	(9)	78.0%	(32)

V1. Internal Barriers toward Engagement

While time and technology may be significant barriers toward engagement within an online community of practice, it is important to investigate internal barriers to engagement, such as participant beliefs about community support. While the frequent mentor/beginning teacher collaboration was a positive indicator for the designers, it was disappointing to note that participation waned in collaborative supports. In particular, it was important for the designers to understand the second order barriers toward the other supports such as the SLC Chats, Blogs, and PDI activities.

An analysis of the participant open-ended responses on the questionnaires revealed that beyond the technical and time constraints, many participants did not see the value in such community-based professional development. The Blogs and SLC chats were viewed as a ‘venting session’ that duplicated the work done with their mentor. Also, because the blogs did not have the capability for participant commenting, some felt that the blogs “feel isolated and artificial, as though I am writing to no one.” Blogging was ranked as the least satisfying component of the program by beginning teachers. In addition, many participants did not see the value or understand the value of the PDI investigation. For some, it duplicated prior or existing professional development activities. While some participants discussed the PDI work with their mentor during their weekly chat sessions, some who participated by posting to the forum began to question if they were posting in the right area due to the lack of participation from other beginning teachers and mentors. Without the interaction with other members, the value of peers to learn with and from may have quickly dissipated. When there was no social interaction with the PDI supports, it became a limited form of interaction between the program and the beginning teacher instead of more social interaction with the mentors and other peers.

Version 2 (V.2) – (Feb 2007 – May 2007)

V.2 – The Knowledge Base Informing the Redesign

From this information on internal and external barriers, the design team began to craft strategies to address some of these barriers through a redesign to be released at the second face-to-face meeting in February. At this meeting, the design team could share modifications to the program and address issues of ‘buy in’ with regards to the value of the supports and value of interaction with the community.

Using the knowledge on the barriers toward engagement within this induction environment from the questionnaires, as well as from participant interaction statistics and logs, and the design team notes and reflections, the design team began to re-imagine the program. First they returned to the knowledge base of online communities of practice literature. The literature informed the team that development of an online community of practice for the professional development of a teacher is a difficult design challenge (Barab, MaKinster, & Scheckler, 2003) as face-to-face meetings may be necessary to build trust required for sharing and engagement. In addition, literature spoke to the importance of quality facilitators within online communities of practice and how they can play a critical role in pushing the thinking of all participants further by making connections to theory and encouraging further discussion (Collison, Elbaum, Haavind, & Tinker, 2000).

Additionally, literature surrounding professional development and adult learning theory was accessed to help inform the redesign of this project. Research supporting notions that adult learners are motivated to engage if they feel that the activities they engage in are relevant to their own context and that they have a sense of choice in their activities in order to ensure that their individual needs are met (Wlodkowski, 1999) was helpful in re-crafting some of the supports.

To ensure that the redesign of the activities could work to meet the needs of the larger community while working to improve their practice, the design team closely examined the changing needs as assessed through the mid-year survey (Table 4) by using a beginning teacher needs assessment (Gordon, 1991). It became clear that additional professional development supports were necessary for classroom management and discipline concerns.

Table 4 – "Choose the response that indicates your level of assistance needed"

	High Need (Oct)	High Need (Jan)
Maintaining student discipline	58%	64%
Obtaining instructional resources	62%	62%
Motivating students	47%	60%
Diagnosing student needs	55%	57%
Organizing and managing my classroom	43%	57%
Managing my time and work	40%	48%
Assisting students with special needs	56%	46%
Planning for instruction	39%	45%

V.2 - The Redesign

The design team set out to redesign the program to better meet the needs of the participants and to increase the interaction of the participants within this online community. At the February meeting, the design team revealed the technical and programmatic changes. During this meeting, which all mentors and beginning teachers were to attend, the design team addressed issues of buy-in, provided a space for community development, and provided additional structure and clarity to the program.

The design team felt it was necessary to re-emphasize the importance of the larger community supports within this program as ways to not only decrease isolation but to help improve the practices of all participants through interaction. To help build community the design team provided time for the mentors and beginning teachers to share stories, to look back across the year to reflect on growth and current concerns, and to set goals based on professional teaching standards and improving practices. They were provided with additional time for the SLCs to meet and discuss issues relevant to them. In addition, the meeting featured interactive breakouts created and led by the mentors. The mentors provided content-specific topics such as ‘discrepant events in science’ and as well a general pedagogical breakouts such as ‘classroom management’, ‘differentiated instruction’, and ‘cooperative learning.’

In addition to re-emphasizing the importance of community, the design team made attempts to provide greater program clarity. To do so, the online site underwent a major overhaul. Many site components were re-arranged so the most pressing and important information was placed at the top of the site. In addition, activity instructions were shortened and modified to provide greater clarity and screen readability. It was critical that the participants could find the information and activities quickly.

To address the issues of time and structure, the design team modified the program requirements. To address some barriers related to time, the design team decreased the mentor/beginning teacher chats to twice a month, decreased the blog entries to once a month, and provided the SLCs with the option to hold their discussion in an asynchronous forum instead of the synchronous chat room; all but two of the SLC groups opted for the forum-based discussion. In addition, a month-by-month checklist was provided to each participant to help them understand the sequence and timing of activities. The design team also re-addressed the purposes and relevance of the activities such as blogging, stressing that blogs are a reflective tool that could not only be used by an individual to look back across growth, but by the group as a place to read others' posts and take comfort that they were not alone in their struggles.

To increase SLC work, the design team redesigned the online SLC meetings to focus on a common topic of concern. Using the data from a beginning teacher needs assessment (Table 4) the design team developed case-based discussions, called Dilemmas, addressing the most pressing topics.[18] Dilemmas were ill-structured problems, modified from actual teacher cases. The structure for the Dilemma activity was that the beginning teachers were to explore the problem first by posting a response to the case and then responding to another beginning teacher. After two weeks the mentors would enter the discussion. The SLCs were also given the option to create their own dilemmas and

[18] Allison Mike, who was a facilitator within the eMSS program, shared the content and structure from the eMSS program called Dilemmas.

have the group work through them. Dilemmas were centered on topics such as classroom management, disruptive individual students, and students with learning disabilities. These topics were chosen to match the needs from the participant survey data.

The PDI was also revised in terms of structure, content, and time. First, the design team decided to assign only one more PDI instead of two. The PDI continued to follow a learning cycle approach, but the design team added a choice of topics that they felt were relevant to the beginning teachers' needs as beginning STEM teachers. Modified lessons from Marzano, Pickering, and Pollock's, (2001) *Classroom Instruction that Works* provided the beginning teachers with a choice of topics such as cooperative learning, non-linguistic representations, inquiry-based instruction, vocabulary, and skills and processes. Beginning teachers were to choose their topic at the face-to-face meeting and began work with their mentor in order to scaffold them into this new system. At the end of the PDI, the beginning teachers were to post a lesson they had taught that used knowledge learned through the PDI to the site wiki. At the end of the program, the wiki gained a number of activities and lessons that all were welcome to use. Additional opportunities for peer interaction through feedback and discussion were built into each PDI activity. Due to the variety of topics, these teachers interacted with general members of the online environment, not with their content-specific peers within the SLCs.

In addition to the program activities and structures, each PDI and SLC group was assigned a facilitator. These facilitators served as members of the group who would help spur on discussion amongst group members by posing questions, linking responses, and summarizing discussion. In addition to increasing meaningful group participation, the facilitator's role was to push the thinking of the participants further. The facilitators would also introduce the PDI and Dilemma topics to their groups instead of the design team.

V.2 - The Barriers After Redesign

After the early February face-to-face meeting, the work of the participants on the site was carefully monitored by the design team to see if there was increased interaction within the site. Results showed that there was a substantial increase in the participation directly after the February meeting. The overall participation within the Blog and SLC activities, as judged against the new, more limited requirements, increased: the SLC posts increased by 18% and the Blog posts by 20%. Within the PDI, there was a participation increase from 46% to 73% of participants engaging in the set of activities. While these numbers were encouraging, there were still some beginning teachers who still struggled to engage. Also, as the end of the school year approached the participation began to wane. Certainly, other barriers toward engaging fully still existed in that were not fully addressed by the redesign.

In addition to the participation data, a 170 question follow up questionnaire was given at the end of the program. There was a 92% (n = 47) response rate. This questionnaire asked the participants to explain what they did and did not value about multiple aspects of the program as well as to explain what they think may have hindered their engagement with each of the supports. The beginning teachers were much more satisfied with redesigned V.2. (65% - very satisfied or satisfied) as compared to initial V.1 (39% - very satisfied or satisfied). Again, while these results were encouraging, the open-ended responses suggested that there were other barriers to overcome.

V.2 - External Barriers

While the participation and satisfaction did increase from V.1 to V.2, time constraints continued to be a barrier for all participants. Although the changes in the program seemed to impact participation, the fluctuation of the program may have been a result of the changing demands on time and energy as the year progressed. One teacher commented that "unfortunately, as school got more stressful, I had less time to try [this program]. If I had a light teaching load, I would have been more engaged. But, ironically, it might have been less helpful." Another participant response highlights the limited energy that many beginning teachers have as they state that they were occasionally, "so drained from the reflection and processing I was doing in my classroom that I was unable to continue in the forums or activities." In addition, the time and energy demands on beginning teachers may lessen as they gain more experience and repeat classes they have already prepared earlier in the school year resulting in less interaction.[19] Regardless, the limited time for beginning teachers, coupled with other external demands for time such as new families, coaching responsibilities, and participation in classes leading toward masters degrees, did appear to impact the amount of time they were able to contribute.

[19] It should be noted that the data suggests that there is no major difference between years of experience and the levels of participation within the induction program

For the participants who struggled to sustain participation, it appears that their lack of time was intertwined with barriers related to the technology used to support this online community of practice. Some participants felt that it was more efficient to engage with their mentor on the phone or in email as indicated by Table 5. One participant echoed this as they stated “I just didn't have the extra time to participate in [this program]. I just wanted to pick up the phone and talk to my mentor, but we were supposed to do everything online which seemed too slow. Maybe I'm old fashioned, but I would rather talk to someone on the phone - I can cover more that way.” Again, these methods of support take away from engagement with the larger community.

Table 5 - *What is your preference for support?*

Response	Count	Percent
Mentor/Beginning teacher Email	12	26.1%
Other Mentor Communication (face-to-face, phone, etc)	9	19.6%
Mentor/Beginning teacher Chat room Meetings	9	19.6%
Mentor/Beginning teacher Forum Messages	5	10.9%
Small Learning Community (SLC) Forum Messages	5	10.9%
Face-to-face Meetings	4	8.7%
Small Learning Community (SLC) Chat Room Meetings	0	0.0%
Small Learning Community (SLC) Chat Room Meetings	0	0.0%

The local context in which beginning teachers taught also functioned as an external barrier toward engagement with this community of practice. For beginning teachers who had district induction programs, the program duplicated some of the work that they did locally. For example, 24% of the participants had a content-specific mentor, 56% reported having ongoing professional development activities for beginning teachers, and 47% had common planning time with teachers in their content area.[20] Some beginning teachers who felt they had sufficient induction support locally chose to not fully participate in all of the induction activities within the online community. However, preliminary analysis suggests there is no significant correlation between the number of local supports and the amount of participation.

In addition to the local support structures, the school and classes in which the beginning teacher taught functioned for some as an external barrier. For those who taught in non-traditional school environments (such as alternative and charter schools), it was difficult to match them with mentors who taught in alternative environments. This caused some difficulty in the mentor/beginning teacher conversations as well as in conversations with peers who were not in similar school settings. For one participant, the PDI did not match his or her context when they state “it was difficult coming from a project-based school, sort of, and making it "fit" into the program model. My lesson planning was sporadic, because in [this school’s vision] there should be very few classes.”

[20] This data does not reveal anything related to the frequency of these supports.

One of the primary external barriers toward engagement within this online community of practice may have been related to a lack of extrinsic motivators for participation; namely credit. Table 6 shows the average level of participation for the different levels of credit for the least popular feature of the program, Blogs. Unsurprisingly, having an external reinforcement such as credit tied to the quantity and substance of postings appears to be related to the level at which they engage within the program, especially in light of limited beginning teacher time and energy.

Table 6 *Blog Posts by Credit Level*

	No Credit	Credit with F2F Course	Credit – Online Only
Mean	1.1	5.3	8.0
SD	1.5	2.6	4.6

However, this does raise the issue of having extrinsic rewards within induction programs, perhaps in the form of a stipend or free credit, as this becomes a costly programmatic venture that may also conflict with conceptions about what it means to be inducted into a community. We must pause to think about beginning teacher motivation for participating in voluntary programs. Do they see this as mainly a convenient tool to get credit to advance their salary through the attaining of Masters Degrees? Do they see the value in such a community-based program as supporting their continued development and the credit as an added benifit? Is there value in participation in either case? While these questions are beyond the scope of this study, it does highlight the importance of ensuring that we align the participant's expectations and motivations for engagement within induction communities with our own expectations and purposes for engagement.

V.2 – Internal Barriers

Participant beliefs about perceived 'connectedness' within an online environment impacted their engagement. Beyond the efficiency of face-to-face or phone conversations with mentors, some beginning teachers did not engage because they did not believe that online environments afford community. One participant noted that "nothing matches or comes close to personal interaction, I'm quite strongly against using technology as a substitute." This comment reveals that they did not feel a sense of connection toward their mentor or the larger community mediated through technology in spite of face-to-face and online community building activities and other components such as profiles and avatars. Another participant echoes that "I did not devote much time to [this program]. [It] relied too heavily on technology. Without a human community, how do you build a web-community?" This finding is supported by research on teacher mentoring that suggests that despite the potential of online mentoring environments, beginning teachers may prefer face-to-face interaction (Shuck, 2003). Research also suggests that in order for participants to engage in meaningful dialog within an online community that they must feel a sense of trust (Barab, Barnett, & Squire, 2002). Community building activities, in both face-to-face and online environments, may serve as an important role in building trust and making connections between the members in order for their work to make stronger connections to their practice through online interactions.

Finally, a less obvious barrier toward engagement was an incompatibility of goals and purposes between the designers and the beginning teachers. Across the participant surveys, the mentor/beginning teacher relationship was seen as the most valuable aspect of the program. Referring back to Table 5 we note that the mentor-based supports (76%, n = 35) were the preferred method of support. When surveyed regarding what aspects of their relationship they found to be most beneficial, many responded that they valued the curriculum, the advice, and the “tricks of the trade” their mentors provided. An email from a beginning teacher who left the program early noted that time was a factor in leaving the program as was an expectation that they would receive “direct and immediate benefits” through participation in the program. Another participant explains that a reason the engagement was lacking was that “I was mostly concerned about classroom management and how to deal with all the paperwork. [This program] seemed to focus more on creating exciting lesson plans - where as I was trying to survive.” Differing conceptions of the role of induction (i.e., immediate emotional, psychological, and technical support vs. support that provides continued teacher learning through ongoing professional development) may have impacted the levels of participation. This finding supports research that suggests that conceptions of mentoring impact what is gained through mentoring (Koballa & Bradbury, 2009). This design concern about the over-reliance on mentoring is also consistent with calls of concern about the over-reliance on mentors as a sole source of induction as mentors may not always promote reform-based practices (Feiman-Nemser, 2001) and that community-based supports can help to share the workload of meeting the multifaceted needs of beginning teachers (Britton & Raizen, 2003).

Summary of Barriers from V.1 and V.2

Below is a table that summarizes the barriers that cut across both versions of the program. While some of the issues, such as a lack of time to participate and the issues of access are mostly beyond the control of online induction designers, many of these issues can be mitigated through careful design.

Table 7 *Summary of Barriers*

External	Internal
a) Lack of training on technology and program activities	a) Lack of understanding and/or buy-in as to value of community-based interaction
b) Lack of time to participate	b) Lack of understanding and/or buy-in as to value of some professional development activities
c) Difficulty arranging synchronous times to meet with mentor and community	c) Feelings that participants were 'participating by themselves' due to a lack of interaction with others
d) Site usability and technical glitches	d) Reliance on the mentor as a sole component of induction
e) Limited internet access at home and/or school	e) Beliefs that meaningful, community-based interaction cannot occur in online environments
f) Preference for quick, and more efficient communication	f) Differing conceptions on purposes of the induction
g) Duplication of local induction support	
h) Contextually irrelevant support activities	
i) Lack of extrinsic reward for participation	

These findings are supported by literature (Gentry, Denton, & Kurz, 2008) on online in-service and beginning teacher mentoring programs in that 1) the availability of hardware and internet connections at schools and at home 2) the time available to participate in the program 3) teachers' comfort with technology 4) the amount of training with the program 5) the teachers' beliefs about the value of the interaction appear to be mediating factors within online induction programs as well. However, induction programs, due to their focus on community-based interaction, multiple supports, ongoing professional development activities, and other components have additional challenges, primarily related to time. Research suggests that release time to participate in induction is an important component of this professional development activity (Ingersoll, 2001). Within this study, a lack of teacher release time to participate with this environment may have impacted the quality of participation within this online environment.

These findings associated with the internal and external barriers related to technology are also consistent with findings from Barab et al. (2003) and Schlager and Fusco (2003) which find that development and sustainability of online communities of practice for purposes of professional development programs are challenging due to the nature of the technological interaction. Kirschner, Strijbos, Kreijn, and Jelle Beers (2004) suggest that educational, social, and technical characteristics of online environments must work together to support the needs of the participants toward sustaining meaningful interaction. In the case of technology-supported communities of practice that are used for purposes of new teacher induction, the beginning teachers' first order barrier of limited time, coupled with any other barriers related to technology usability issues or perceptions on the role of technology in forming meaningful relationships may have substantially limited both the quantity and quality of their participation.

From an induction designer perspective, technology provides an additional challenge in the enactment of meaningful professional development. Within face-to-face induction efforts, an induction designer may be able to make rapid changes to the structure of the educational and social supports as determined by interaction and by participant questions. However, with online environments, designers have to work harder to ‘read’ participant confusion, levels of engagement, and other ‘tells’ that help to guide and modify the design and implementation of the professional development. Even if there are quality educational supports and meaningful opportunities for collaboration with peers, issues with technological components of the environment may cause substantial confusion and ultimately lead to a lack of participation. The following sections will briefly discuss some ways to mitigate these barriers as well as provide discussion on how the knowledge of these barriers informed a new design.

Discussion - Mitigating the Barriers

Ala-Carte Models

When designing comprehensive online induction systems we must account for the individual teachers’ local support systems and contexts toward developing an “ala carte” system that accounts for local contexts so efforts are not duplicated. For example, induction programmers within different districts choose from a suite of available supports to provide a more comprehensive, systemic induction system for their beginning teachers. For example, a teacher in rural district that lacks a content-specific mentor or peers could participate with the entire suite. However, a teacher with a content-specific mentor within an urban setting could participate in a SLC group or within a PDI activity.

Challenging Conceptions of Mentoring and Preparing Quality Mentors

The finding that beginning teacher over-reliance on mentors acts as barrier toward engagement with the rest of the supports, should give induction designers pause to reflect on how to help beginning teachers engage with the set of supports. The open-ended responses indicate that some beginning teachers see their mentor relationship as providing timely resources and advice to help them survive. The danger with this conception is that this puts the mentor/beginning teacher relationship one of the mentor as the provider of on-demand technical and emotional assistance. This is in contrast to community-based conceptions of induction that work to move past deficit notions of teacher support in which the goal of the beginning teacher is to provide support to help them survive their first years of teaching (Achinstein & Athanases, 2006). While mentor relationships under these conceptions may help provide encouragement during the difficult times, care must be taken that their work helps induct these teachers into the communities' way of thinking and knowing. In addition, there is danger if the advice or curriculum these mentors provide is contrary to the vision of reform-based practice within each domain (Feiman-Nemser, 2001).

With the heavy reliance on mentors as a primary means of support, it becomes critical to address the selection and professional development of mentors. It is important to find mentors who are subject-specific matches, have the ability to implement reform-based science instruction, and can play a variety of roles within the mentoring relationship (e.g., from guide, facilitator, instructor within the emotional, technical, and logistical areas) (Feiman-Nemser, 2001). In addition, it is critical that these mentors can encourage and guide participation through a set of professional development activities that include interaction with peers and other experienced mentors in sustained, content-specific professional development activities. Community-based learning object repositories of reform-based lesson, activities, and resources can also take some of the load off the mentor as the sole curricular provider. These databases can provide reform-based activities and lessons that can be adapted to the needs of their individual contexts and students.

Furthermore, designers can provide opportunities for exploration of visions of teaching knowledge and expertise that are multifaceted (Bransford, Darling-Hammond, & LePage, 2005; Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee, 2002), content-specific and that provide opportunities for formative assessment along those domains. These interactions may help beginning teachers to set professional goals that impact their individual practice and help them to choose and engage in the multiple supports in ways that make sense to them. This will help beginning teachers to address the challenges of implementing reform-based instruction within each of the STEM domains through interaction with an induction program that is consistent with the larger community's view of reform-based practice (Wang, Odell, & Schwill, 2008).

Blended Models of Induction

When asked about the most important aspects of the program one beginning teacher stated, "The [face-to-face meetings were] very encouraging to me. Knowing I was not "alone" in the fight was very useful," and while many other participants cited this interaction with their experienced and novice peers as important for decreasing isolation[21] through interaction within this online learning environment, this beginning teacher specifically cited the face-to-face meeting as important in decreasing isolation. Indeed, for some participants, these face-to-face meetings provided a space for emotional release. A face-to-face interaction with one beginning teacher in which one of the designers asked why they had not seen them online lately and wondered how their first year was progressing provoked a response in which the beginning teacher expressed that things were 'fine.' When the designer asked if things were truly 'fine' the beginning teacher broke down in tears and began to tell her story. For some teachers, this deep emotional reaction may not have been possible in an online environment. Online chat rooms and forums miss the subtle voice and body cues that can tell a mentor when things are not 'ok.' This alone may give credence to the important, yet expensive challenge, of connecting teachers occasionally in a face-to-face environment.

[21] See 'Affordances' chapter

It is important to note that even though online learning communities and future versions of the program that connect users through VOIP video conferencing have the power to connect communities in an efficient way, there is sometimes no substitute for handing someone a tissue when they are at their lowest point. Providing emotional support by attending to such needs is an important component of induction. As designers, we cannot forget these online induction programs are a 'community of practice supported though technology' not a 'technology-based community of practice.'

Implications for Current Design

The design teams' current V.3 design, Project TIN (Science Teacher Induction Network), uses the knowledge of these barriers toward developing a more effective and efficient technology enhanced community of practice. It uses a system of beginning teacher formative evaluation in which the beginning teachers and their mentors interact. This ongoing formative evaluation system helps beginning teachers and their mentors to choose and design personalized professional development activities. In addition, the focus on solely science teacher induction instead of providing content-specific induction for STEM, had helped to develop more content and more content-specific professional development activities linked to the development of domain and topic level pedagogical content knowledge (Veal & MacKinster, 2001) instead of relying on mentors and facilitators to focus the conversation at this level. Additional content supports such as a learning object repository through an open source program called LeMill have provided a more efficient resource bank of reform-based lessons. In addition, collaborative technologies have been implemented to promote the co-development of lessons between mentors and beginning teachers within the PDI activities. Also, the design team has moved toward a more face-to-face form of interaction through synchronous VOIP web-conference rooms that have the capability for synchronous video and multimedia resource sharing. Future designs will explore the role of annotated video systems for purposes of teacher observation to aid implementation of the PDI activities. The following diagrams highlight the barriers from V1/V2 and highlight some of the corresponding design considerations for Project TIN.

Table 8 *External Barriers Design Considerations*

External Barriers from V1/V2	Design considerations for Project TIN
Lack of training on technology and program activities	Provide face-to-face training on the technology and program activities
Lack of time to participate	Limit required participation and push for beginning teacher release
Difficulty arranging synchronous times to meet with mentor and community	Offer flexibility in access
Site usability and technical glitches	Engage in usability testing
Limited internet access at home and/or school	Limit the technical requirements for bandwidth and

	hardware
Preference for quick, and more efficient communication	Design more efficient modes of communication (instant messaging, etc) and more interactive modes of communication that provide more meaningful and authentic activities such as collaborative document creation, video analysis
Duplication of local induction support	Provide ala-carte models
Contextually irrelevant support activities	Provide more options and flexibility for professional development activities
Lack of extrinsic motivations for participation	Carefully consider either credit or stipend based rewards

Table 9 *Internal Barrier Design Considerations*

Internal Barriers from V1/V2	Design considerations for V3 Project TIN
Lack of understanding and/or buy-in as to value of community-based interaction	Reveal and confront conceptions of community-based induction through activities that build community
Lack of understanding and/or buy-in as to value of some professional development activities	Reveal and confront conceptions of induction PD through activities and marketing
Feelings that participants were 'participating by themselves' due to a lack of interaction with others	Ensure that facilitators help sustain participation and that interaction at minimum occurs between mentors and facilitators

Reliance on the mentor as a sole component of induction	Address importance of the suite of supports
Beliefs that meaningful, community-based interaction cannot occur in online environments	Build community through face-to-face interactions and carefully scaffold into online environments
Differing conceptions on purposes of the induction	Continually address vision of induction that is consistent with larger community's vision for reform-based teaching

Conclusion

As designers, we must explore and challenge the individual beliefs that our beginning teachers bring to the community that may be counter to conceptions of comprehensive, systemic induction that supports reform-based instruction. If we are to be a true community of practice that connects pre-service, in-service, local and national teacher organizations, we must have a common, yet evolving set of goals and aims that is open to thoughtful discourse based in praxis. Great care must be given to the design of online communities in order to help our newest members become full participating members of the community in which they work in order to help bring others into the community towards the improvement and reform of teaching practices for all.

Finally, it is critical to keep in mind the external demands placed on beginning teachers as they transition from a relatively safe and structured environment of student teaching toward an environment in which they must perform the same tasks as a 30 year veteran. These demands placed on these teachers weigh heavily on their available time and energy. However, induction designers must also keep in mind potential external and internal barriers toward engaging within an online community of practice. Induction programs must be seen by beginning teachers as a help toward their development during these challenging times and not merely as a tool for survival. They must see how online communities of practice, in which they learn from and with each other can help them to both survive and thrive.

Chapter 4: Taxonomy of Beginning Science Teacher Challenges

Background

Beginning science teacher retention has been a topic of concern among policy makers, professional organizations, teacher educators, schools, and other stakeholders. Studies suggest that teachers leave the profession at rates of up to 50% within the first five years of their practice (Ingersoll, 2001). These high rates of attrition have created 'revolving doors' of beginning teachers within many high-needs districts (Ingersoll, 2001). For science education, the need to retain qualified teachers is more acute, because there is a more limited supply than other teaching fields (Ingersoll & Perda, 2006). These high levels of attrition, coupled with the eminent retirement of the baby-boom generation (National Commission on Teaching and America's Future, 2009) have caused policy makers to seek solutions to recruit and retain qualified science teachers.

Induction programs have been promoted as a potential solution for alleviating some aspects of job dissatisfaction that lead to attrition. While nationally it is reported that up to 90% of teachers receive some kind of induction support usually in the form of mentoring (Smith & Ingersoll, 2004), science teachers are less likely to participate in induction supports, with rates as low as 57% in the poorest school districts (National Science Board, 2008). Even if these teachers participate in induction programs, not all beginning science teachers are matched with a content-specific mentor who teaches the same science discipline. Finding these mentors is challenging in small charter and rural schools as these teachers may be the only science teacher of their kind, leaving beginning science teachers to face content-specific challenges on their own.

While induction programs can impact retention (Ingersoll, 2001), some have raised serious concerns about focusing induction supports solely on meeting the goals of retention. For example, Feiman-Nemer (2001) raises issue with induction programs that provide supports for retention when she writes:

> Support is the omnibus term used to describe the materials, advice, and hand-holding that mentors offer new teachers. While supporting new teachers is a humane response to the very real challenges of beginning teaching, it does not provide an adequate rationale. Unless we take new teachers seriously as learners and frame induction around a vision of good teaching and compelling standards for student learning, we will end up with induction programs that reduce stress and address immediate problems without promoting teacher development and improving the quality of teaching and learning. (p. 1031)

Other researchers have echoed the importance of framing induction around standards-based visions of teaching (Wang, Odell, & Schwill, 2008). Within research in science education, Koballa and Bradbury (2009) argue that mentoring within induction programs should "advance standards-based science education reform, while at the same time addressing the science-specific needs of beginning teachers at all schooling levels" (p. 171). These goals are consistent with visions of induction supports that are multidimensional (Gold, 1996) and can provide psychological/emotional, logistical, and instructional support (Feiman-Nemser, 2001) through sustained, content-specific professional development activities with experienced and novice peers (Darling-Hammmond & Richardson, 2009; Ingersoll, 2001).

It may be possible to both meet the immediate concerns of beginning teachers that impact job satisfaction and help them improve their understandings and practices. By understanding and leveraging beginning teacher challenges we can build targeted professional development support activities. Leveraging challenges may provide relevance that is important to adult learners (Wlodkowski, 1999) and that may help encourage beginning teacher engagement with induction activities. Within this vision of induction, the role of the mentor becomes less of a source of expert advice, resources, and training (Gold, 1996) and becomes more of a source of guidance that helps the beginning teacher address challenges while improving the beginning teacher knowledge and practice. By doing so, we can help the beginning teacher to address immediate concerns that may cause job dissatisfaction while helping them to improve along the multifaceted dimensions of practice. This study will explore the challenges that beginning science teachers face to help meet this end.

Review of Relevant Literature

In designing induction supports and preparing content-specific mentors it is important to understand the range of challenges that beginning science teachers face. The most commonly cited work[22] on new teacher challenges is a study by Veenman (1984) that reviewed 83 studies of elementary and secondary beginning teachers from 1960 to 1984. In this study, a beginning teacher problem is described as, “a difficulty that beginning teachers encounter in the performance of their task, so that intended goals may be hindered” (p. 143). A large majority of the review studies were of questionnaires and with some interview studies. Veenman created a rank order of the 24 most common problems beginning teachers faced based on the frequency in which they appeared within the study (see Table 10).

Table 10 *Veenman (1984) Perceived Problems of Beginning Teachers*

Rank order	Problem
1	Classroom discipline
2	Motivating students
3	Dealing with individual differences
4.5	Assessing students' work
4.5	Relations with parents
6.5	Organization of class work
6.5	Insufficient materials and supplies
8	Dealing with problems of individual students
9	Heavy teaching load resulting in insufficient prep time
10	Relations with colleagues

[22] 785 citations according to Google Scholar, 3rd most frequently cited within the Review of Educational Research

11	Planning of lessons and schooldays
12	Effective use of different teaching methods
13	Awareness of school policies and rules
14	Determining learning level of students
16	Knowledge of subject matter
16	Burden of clerical work
16	Relations with principals/administrators
18	Inadequate school equipment
19	Dealing with slow learners
20	Dealing with students of different cultures and deprived backgrounds
21	Effective use of textbooks and curriculum guides
22	Lack of spare time
23	Inadequate guidance & support
24	Large class size

Researchers (Gold, 1996) have raised concern about Veenman's work as it relates to the lack of focus on the relationships between subject matter knowledge and pedagogical knowledge and relationships between management and teacher instructional choices and curriculum (Gold, 1996). Gold (1996) has argued that developing induction programs based on Veenman's work can lead to the development of programs that provide a focus on classroom management support and not on the complex processes of teaching such as acquiring and enacting pedagogical content knowledge and reflecting critically on teaching. In addition, Veenman's work reviews studies that are not set within the current frame of reform-based practice, are mainly self reported data, and most importantly, do not frame challenges as related to the teaching of specific content.

A review of research within science education literature[23] found eight studies that explored at least one aspect of challenges that secondary science teachers faced. From this set, none of these studies explicitly focused on the broad range of challenges that new science teachers face due to their limited focus on particular aspects of instruction. Four of these studies had three or fewer participants. Despite these limitations, these studies can provide a useful starting place for this investigation.

From this set of studies we find that beginning teachers face challenges related to time (Bianchini, Johnston, Oram, & Cavazos, 2003; Loughran, 1994), limited resources (Bradford & Dana, 1996), content knowledge (Roehrig & Luft, 2004), pedagogical knowledge (Roehrig & Luft, 2004) and challenges related to maintaining student centered classroom environments (Simmons, 1999; Eick, 2002; Roehrig & Luft, 2006). Other studies examined beginning teachers' perceived disconnections between beliefs and practices (Bradford & Dana, 1996; Sweeney, Bula, & Cornett, 2001).

---

[23] based on searchers within Davis, Petish, and Smithey (2006) review of research on the challenges pre-service and induction science teachers face and citations linked to Veenman's study related to science education

One study in this set, by Adams and Krockover (1997), presents the most comprehensive set of challenges that eleven new mathematics and science teachers faced. Based primarily on a single, self report phone interviews, the research team identified the challenges these teachers faced. These challenges are classified as related to 'Job Assignment' and to the 'Art and Craft of Teaching'. Within 'Job Assignments' they found that teachers faced difficulties because they were asked to teach outside of their content area and to be the primary curriculum developers. This study does not explain the difficulties they faced within these tasks. Within the 'Art and Craft of Teaching' they found that beginning teachers struggle with time management, especially as it relates to balancing personal time and energy, personal energy and classroom discipline. In addition they find that some beginning teachers struggle with content knowledge and subject matter pedagogy. This study does not reveal what components of subject matter pedagogy, classroom management, or content knowledge that these beginning teachers struggled with. In addition, because this is a study of both mathematics and science teachers, it is difficult to understand in what ways these challenges are unique to the teaching of specific mathematics and science knowledge. Table 11 provides a brief summary of the challenges new science teachers face from the literature:

Table 11 *Literature on beginning secondary science teacher challenges*

Challenge	Citations
Limited time	Bianchini, Johnston, Oram, & Cavazos, 2003; Loughran, 1994; Adams & Krockover, 1997
Limited resources	Bianchini, Johnston, Oram, & Cavazos, 2003
Classroom management	Simmons, 1999; Eick, 2002; Luft, Roehrig, & Patterson, 2002; Adams & Krockover, 1997
Challenges related to content knowledge	Adams & Krockover, 1997; Roehrig & Luft, 2004
Challenges related to pedagogical knowledge	Adams & Krockover, 1997; Roehrig & Luft, 2004

There is a need to lay out the broad landscape of the comprehensive challenges secondary science teachers face. It is important to explore which particular challenges they face within large categories such as classroom management and pedagogical knowledge and how this relates not only to context, but to content. Missing from the literature is a comprehensive understanding of challenges of learning to teach science from a contextual and content-specific perspective.

Research Questions

This study explores the challenges beginning science teachers face as expressed through dialog with a mentor within a content-specific online induction program for beginning science teachers. Understanding challenges may not only help to better understand sources of job-dissatisfaction, they can more importantly help to better understand how these challenges may be related to gaps in pedagogical knowledge, content knowledge, and pedagogical content knowledge as well as issues related to the enactment of this knowledge. In addition to constructing a landscape of challenges these beginning science teachers faced, this study will explore the ways in which these challenges relate to the teaching of specific science concepts and provide suggestions as to how content-specific induction can help beginning teachers address and learn from these challenges through sustained professional development. This range of challenges will be transformed into a taxonomy for classification purposes and for future research. In addition, it can provide meaningful 'jumping off points' for professional development investigations and can help to fill gaps in research-based knowledge of the challenges that teachers face from a content and context specific lens.

This study conceptualizes a critical component of teacher knowledge as related to pedagogical content knowledge. Pedagogical content knowledge (Shulman, 1986), which is the integration of pedagogical knowledge, content knowledge, and contextual knowledge (Grossman, 1990) includes:

> the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations--in a word, the ways of representing and formulating the subject that make it comprehensible to others. Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. (Shulman, 1986, p. 9)

This study further frames pedagogical content knowledge around four hierarchical levels (Veal & MaKinster, 1999); general pedagogical knowledge, discipline-specific pedagogical knowledge (e.g., science vs. math), science subject specific pedagogical content knowledge (e.g., physics vs. chemistry), and science topic-specific pedagogical content knowledge (e.g., thermodynamics within chemistry vs. thermodynamics within physics). Research suggests that discipline-specific induction programs may play a role in developing science specific pedagogical content knowledge (Luft, Roehrig, & Patterson, 2002).

Context of Data

This study examines challenges as expressed within an online induction program for non-tenured STEM educators in a Midwestern state. During the 2006-2007 school year, this program served 65 beginning teachers, 35 of whom were in secondary science. The goals of this program were to increase the retention of teachers and to improve beginning teacher performance. To combat job dissatisfaction caused by isolation and a lack of local supports, this program utilized both synchronous and asynchronous technologies to connect beginning teachers with content-specific mentors and a community of their peers. Activities targeted toward the needs of these teachers were provided to help improve reflective, reform-based practices, through activities such as mentor/beginning teacher chats, case-based discussions and 'Professional Development Investigations' or PDIs. These PDIs were a sequence of activities in which the beginning teachers worked with their mentors in planning, implementing, and reflecting on a lesson with a specific pedagogical focus.

The most commonly utilized support within this program was the mentor/beginning teacher chat. This was a private area for conversations between mentors and beginning teachers. Each beginning teacher was assigned a mentor who taught a similar content area and if possible, in a similar context (e.g., rural, suburban, urban). The beginning teachers were required to meet at least weekly with their mentor in either a private synchronous chat room or through a sustained conversation within an asynchronous private discussion board. The primary goal of the mentor/beginning teacher conversation support were to meet the immediate needs of the beginning teachers while simultaneously helping the teacher to refine their repertoire of reform-based practices (Feiman-Nemser, 2001). It was hoped that interaction through these content-specific conversations would help to continue the development of pedagogical content knowledge (Grossman, 1990; Shulman, 1986), improve the learning environment of their classrooms, and provide support with additional aspects of practice as needed.

Sources of Data

To understand the challenges these beginning teachers face, this study focuses its analysis on the synchronous chat room sessions between mentors and the beginning teachers over a six month period. The synchronous chat rooms were selected for analysis because although there are differences in speech patterns and turn-taking in this form of computer mediated communication, it is similar to patterns that would take place in a face-to-face or phone conversation with a mentor. Some sessions dedicated time to working with mentors on the PDI, however, a majority of these sessions were unstructured conversations. These chat room sessions provide a unique, somewhat naturalistic source of data that data contains the actual words of the beginning teacher within a context of conversation with a content experienced mentor.

Moodle, an open source learning management system, provided the platform for the induction program and the source of data for this study. This platform logged participant interaction and recorded the text-based conversation between the beginning teacher and their mentor. Of the 35 science participants, 24 of these participants were chosen for analysis due to their choice of the synchronous chat room sessions as their primary form of communication with their mentor as opposed to the asynchronous forum discussions. On average, each of the 24 participants communicated eight times (SD = 4.1) for an average of 39 minutes per conversation (SD = 14.4) over a period of six months resulting in a total of 196 chat room sessions.

The following provides background on this diverse group of beginning teachers in the study:

a) 9 out of the 24 do not have licenses for the subjects they taught yet all had content area backgrounds in the science
b) 3 had a local mentor who taught the same domain, 4 had a local mentor who taught science but not in the same domain, 9 had a local mentor but not in science, 12 had no mentor
c) 7 taught in urban, 3 in rural, and 14 in suburban schools
d) 19 taught in traditional school structures and 5 taught in charter and alternative schools
e) 17 taught in a high school setting and 7 in middle school settings
f) 12 were first year, 9 second year, 1 third year, and 2 in their fourth, but were not tenured

Method of Data Analysis

This qualitative study uses an inductive approach to data analysis (Miles & Huberman, 1994) in this naturalistic setting in order to explore the dialog within the chat room sessions. While no a priori codes were developed, it should be noted that the author's prior knowledge developed from work with pre-service science teacher education, induction programming and mentoring, and experience as a secondary science teacher helped to shaped the initial codes.

Operationalizing Challenges

To begin the process of coding, the chat room transcripts were read line by line, one participant at a time. As the chat room sessions were read, the author searched for phrases that indicated a challenge. A phrase was classified as a challenge if it was 1) an expressed frustration, uncertainty, or concern, 2) was a question directed at the mentor, or 3) was a story that did not have resolution. A challenge could be a problem that impacts an intended goal (Veenman, 1984) and/or could be related to a source of emotional/psychological stress.

While a beginning teacher may not classify a particular question/statement/story directed at a mentor as a challenge, we as teacher educators, mentors, and those involved in induction systems may choose to classify their statement as a challenge if it reflects issues of enactment, a potential gap in knowledge, or a sense of uncertainty toward the course forward.

The following example provides some clarification to this distinction. In a conversation with a mentor regarding laboratory activities, a beginning teacher responds to a question from the mentor about available facilities for laboratory instruction. The beginning teacher responds that "there is not a special room for the labs though. I just move to four different classrooms depending on the period. I just wheel the cart of microscopes along with my cart of other supplies. It keeps me busy and the time goes by so fast." Later in the conversation, the mentor notes that this must be challenging for the teacher. While the text indicates that the beginning teacher has adapted to this environment, besides the comment that it 'keeps me busy and time goes by so fast,' they may not have necessarily indicated the lack of proper facilities as a challenge. However, the mentor, the author, and two additional researchers[24] in inter-rater reliability sessions, chose to identify this as a challenge.[25]

Process of coding and creation of the taxonomy

Using NVIVO qualitative data analysis software, statements that could be classified as a challenge were coded using the text of the statement as a code, or 'in vivo' codes (Glaser & Strauss, 1967). After reading several participant transcripts, these 'in vivo' codes were grouped into larger conceptual 'bins' or categories such as General Pedagogical Knowledge, Classroom Management, and Pedagogical Content Knowledge. Memos were used to give initial meaning of these categories based on personal prior knowledge and reviews of literature.

Returning to the data, other participant transcripts were then read and additional 'in vivo' codes were created. These codes were then sorted into the larger 'bins.' If they did not fit into existing categories, additional categories such as 'Context' were created.

---

[24] Special thanks to Sarah Hick and Mary Sande for their gracious assistance with inter-rater reliability

[25] It should be noted, through inter-rater reliability discussions, that this was one of the only statements that could not be quickly coded as a challenge.

This iterative process continued with occasional coding checks to ensure that the ‘in vivo’ codes fit in each of the bins.

As more ‘in vivo’ codes were created and sorted the author began to create sub-categories within each of the larger categories. These sub-categories were given a short description to ensure there was internal consistency. These sub-categories were created not necessarily based on frequency, but on the uniqueness of the challenge. The process continued through additional ‘in vivo’ coding of transcripts, sorting into codes into larger categories, and then into the sub-categories.

Using constant-comparative methods (Glaser & Strauss, 1967) to provide internal consistency, frequent checks of the original context of the ‘in vivo’ codes were done to ensure that that the code fit within the category and sub-category. This process of coding transcripts to produce ‘in vivo’ codes, sorting codes into categories and sub-categories, internal consistency checks, and the iterative refinement of coding category descriptions continued until all transcripts were analyzed. The codes, sorted into categories and sub-categories were then transformed into a series of tables and a comprehensive table that could show the range or ‘taxonomy of challenges’. The set of ‘in vivo’ codes within each of the categories and sub-categories within the taxonomy was reviewed to ensure final consistency, and code frequencies were calculated.

As an additional level of analysis, the taxonomy was examined through the lenses of personal prior knowledge and literature to explore what was anticipated, what was not expected, and what was missing, as well as an exploration as to why certain challenges were faced and how beginning science teachers could receive support for these challenges.

Inter-rater reliability and member checking

To provide a more reliable set of data, inter-rater reliability assessments were done with external researchers. A sample of the data was selected for analysis based on the richness of the conversation. The raters were mentors in this study, but did not code their own conversations. The raters were given the code book that contained descriptions of the 83 categories and sub-categories and were then asked to code three transcripts one at a time. Agreements and disagreements were discussed and tallied. Across the three transcripts, there was an initial agreement of 122 out of 138 possible codes for an 88% agreement. Many of the 'disagreements' were due to missed codes by the author. For the second round of coding the inter-rater reliability was approximately 96%.

In addition to inter-rater reliability, the set of codes, represented by the taxonomy was given to selected mentors and beginning teachers in this study. This form of member checking (Glaser & Strauss, 1967) was useful in determining if the headings were clear and if they felt the table was complete. Throughout this analysis, the mentors and beginning teachers provided additional codes that they felt were missing from this study. However, these codes were not included because they were not represented in this data. A discussion of these 'missing' codes will be provided later.

Limitations of this study

The analysis of this data may be limited by several factors. For example, conversations at times were driven by the mentor and limited the beginning teacher's ability to discuss freely the challenges he or she was facing, especially when immediate advice was given. For some beginning teachers, the technology served as a barrier toward meaningful communication due to beliefs that mentoring could not take place online.[26] In addition, text-based chat misses tonal and body language clues that could help mentors interpret meaning that could drive the conversation toward the exploration of challenges. Finally, this program began in October instead of beginning in August when the school year started, so the documented challenges may not be fully representative of the challenges beginning teachers face within the first weeks of school.

Results

When the coding was completed, 167 of the 196 (85%) sources had at least one code as a challenge. From the 196 sources there were an average of 5.2 challenges per source (SD = 3.9) with a total of 874 statements that were coded as challenges.[27] Each of the 24 participants had at least one chat session that contained at least one challenge, with each participant averaging 4.1 challenges per source (SD = 2.6). On average, participants were coded as having 10.3 challenges (SD = 7.9) during their participation.

---

[26] See Barriers study

[27] Thirteen of these 874 codes were coded in an additional category as they did not fit cleanly into one sub-category

The following sections will briefly discuss each of the main categories. The sub-categories are presented here in alphabetical order. The purpose of this study is break convention from ranked orders of concern such as provided in the Veenman (1984) study to provide an exploration of the range of challenges that beginning science teachers face. Focus of professional development support on a top ranked challenge, such as classroom management within the Veenman study, may not adequately address the individual challenges that beginning teachers face and may lead the reader to ignore how these individual challenges may be related to one another.

The 'in-vivo' codes are used to highlight examples of challenges within sub-categories. They are presented in their original form, except for spelling and occasional brackets. Each section will highlight some of the sub-categories, particularly as they relate to the teaching of science, and will begin to explore how content-specific mentoring may be able to help address these challenges.

The first column provides a short identifier for the sub-category and the second provides a brief definition. The 'participants' column refers to the number of participants that were coded with that challenge (out of 24), the 'sessions' column refers to the total number of chat room sessions that included at least one of the sub-category challenges (out of 196), and the 'total' column refers to the total number of phrases coded with that challenge (out of 874).

Table 12 *Challenges related to Student Academics*

Category	Description	Participants	Sessions	Total
Student academic		14	26	45
a) Student effort related to improving personal understanding	Challenges related to teacher concerns that students understanding and academic success is hampered by their not working through challenges	3	4	4
b) Students failing courses	Challenges related to student failures in courses	3	4	4
c) Student effort related to completing assignments and other tasks	Challenges related to students that are not completing tasks, assignments, and other work in or outside of class	9	15	19
d) Student performance on formal assessments	Challenges related to understanding why students that are struggling to perform on formal assessments	5	6	7

e)	Working with parents on student academic issues	Challenges related to working with parents to improve the academic performance of their students and conflicts over grades	4	5	11

The ‘Student Academic’ category refers to a general set of challenges related to student academic issues. While the conversations are within the context of a science classroom, the conversations and challenges stated stay at a general level; that is they do not become discipline or topic-specific. For example one participant explains that “I am at a crossroads with ionic compounds...many of the kids are just not getting it, but most of the ones not getting it are not doing any work either...so my juniors just sit and complain, but won’t read the textbook book or look at their notes and it seems no matter how many times I sit and do examples with them, they just do not bother to look back at them...I am really frustrated.” While this quote reflects a specific issue regarding student understanding of ionic compounds, it mostly reflects a challenge related to the belief that the reason students are not succeeding is that they do not work through their assigned problems. The range of codes in this category focuses mainly on students and their effort and performance on assessments. As in the above example, many of the ‘in vivo’ codes focus on what the students are or are not doing and less on what role the comprehensive instruction and learning environment play in helping support student learning.[28]

Other related challenges deal with working with parents on academic issues. One participant states, “I agree completely about the pressure parents put on their kids. It is a bit obnoxious at times. Some kids are just B or C students.” This challenge may be related to a conception of learning based on a fixed view of intelligence.

[28] Thanks to Sarah Hick for helping to identify this pattern

Table 13 *External Challenges*

Category	Description	Participants	Sessions	Total
External		8	16	17
a) Finding new employment	Challenges related to the need for a new teaching position caused by a variety of reasons	5	6	6
b) Lacking support from partner	Challenges related to a lack of support from a partner	2	2	2
c) Masters coursework	Challenges related to coursework for masters degree are placing a demand on time and energy	2	3	3
d) Voluntary extracurricular	Challenges in which voluntary extracurricular work during the school day and beyond places demands on time and energy	4	6	6

In this set of sub-categories, we see external demands on time and energy that are beyond the scope of the classroom. For example, we see challenges related to the time required for master's coursework and extracurricular work. In addition, we find other stressors such as the need to find new employment and a lack of support from a partner.

Table 14 *Challenges related to teaching diverse learners*

Category	Description	Participants	Sessions	Total
Diverse Learners		9	11	15
a) ELL/SLC Students	Challenges related to teaching students who have issues related to second languages and cultures	3	3	6
b) Special education students	Challenges related to instruction of students who have learning disabilities and may be receiving special education services	6	7	7
c) Students with exceptional psychological challenges	Challenges related to students with severe personal issues and behavior in which counselors and other staff are involved	2	2	2

In this set of challenges, we see that some participants struggle when working with students who have learning disabilities, such as those highlighted in the 'special education/504' sub-code. In the ELL/SLC, teachers express challenges related to how they can improve instruction to meet the needs of these students. During member checking, mentors suggested that working with gifted learners may be missing from this list, yet working with gifted learners did not appear within the data. It is interesting to note that issues related to teaching students with diverse student cultures is not more prominent beyond the work with ELL/SLC students.

Table 15 *Personal Beliefs, Attitudes, and Concerns*

Category	Description	Participants	Sessions	Total
Personal beliefs, attitudes, and concerns		16	54	103
a) Concern about a general lack of content knowledge	Challenges related to general comfort in teaching a content area due to content area knowledge limitations	5	7	7
b) General frustration with profession	Challenges related to general frustrations with the profession and it's tasks	3	3	4
c) Lack of time and energy to be effective	Challenges related to the lack of time and energy that is draining personally and impacting ability to teach in the ways they envision	12	28	46
d) Mental health issue impacting teaching	Challenges related to extreme anxieties that are impacting teaching	1	3	3
e) Preference for different age	Challenges related to a preference for a different age	3	3	3

	group	group			
f)	Self described challenges of being a new teacher	Challenges related to a belief that their frustration is part of the process of learning to teach that will be better with more experience	8	13	17
g)	Self efficacy (not CM related)	Challenges related to beliefs that they are not effective teachers due to a variety of dimensions of practice and personal attributes	6	15	23

This set of challenges refers to a set of personal beliefs, attitudes and concerns that may impact instruction and job satisfaction. Of particular interest are the codes relating to the lack of time and energy that appears to impact their sense of well being and ability to do their job effectively. A majority of these concerns relates to the day-to-day nature of planning that may conflict with their vision for teaching science. One participant expresses these concerns when they lament that they, “look over materials...write the objectives and activities...then do individual lessons after doing the unit lesson...it worked well when I was student teaching, but right now...no time...day-to-day which is not the way I prefer to work...I prefer to see the unit as a whole with clear objectives to check, but I am just trying to get by these days.” Another participate states that, “I could definitely stand to be more reflective. I am just too tired to do it.”

Coupled with this set of codes, we see a number of codes related to the ‘Self described challenges of being a new teacher’ in which they believe that the challenges they face are related to becoming a new teacher and will lessen with time. One participant states, “I feel like I am not myself when I haven’t taught the material before, probably because I am not confident in it.” Other comments in this sub-code deal with frustration related to how they envision themselves as teachers and how their lack of experience hampers this.

Within this larger category, we see a set of general self efficacy statements, not solely related to classroom management. In this sub-category we find beliefs that they are ineffective as teachers, are not confident in how they are teaching, and are often nervous. When a mentor tells their beginning teacher that they may be over-critical of themselves the teacher responds, “I know that I tend to be tough on myself... I am trying to be more positive about how I reflect on what I am doing, but I find it really hard.”

It should be noted that the participants were prepared and licensed in the state in which this program originated, all had licensure in at least one science area, yet a number of the participants were teaching out-of-field; that is, they were teaching science courses for which they were not licensed. This may have led to codes related to content knowledge concerns. For example, when discussing a demonstration to do in a chemistry class that one participant was not certified to teach, they responded with concern stating that “fear of chemicals and explosions = biologist.” It should also be noted that some participants expressed concerns most likely related to the transformation of content knowledge. One teacher states “I feel so overwhelmed by how little I know...sometimes it feels like I am re-teaching myself chem[istry] all over again.” Teacher content knowledge and abilities to transform this knowledge may relate to feelings of self efficacy and a lack of time and energy.

Table 16 *Challenges Related to the Context of School or District*

Category	Description	Participants	Sessions	Total
Context of school or district		21	63	122
a) Class length too short	Challenges related to the length of class periods, (sometimes temporarily shortened) or the number of instructional days limits what can be taught and how it can be taught	3	4	6
b) Class size too big	Challenges related to large class sizes making classroom management and activities difficult to implement	5	5	5
c) Concerns about student population	Challenges related to the illegal behavior, SES, contexts, and efficacy of the student population.	3	4	6
d) Curriculum mandates and constraints from staff or school	Challenges related to formal or informal mandates from staff and administration on what content is taught, how content is taught, and for how long	6	7	11

e)	Issues with administration	Challenges related to interactions with administration that cause job dissatisfaction	5	8	11
f)	Issues with district	Challenges related to issues within the district	3	4	5
g)	Issues with staff	Challenges related to conflicts with other staff	7	10	14
h)	Lack of equipment and resources	Challenges related to a lack of proper equipment and resources to teach science	7	10	12
i)	Lack of local induction supports	Challenges related to a lack of induction supports such as lacking content-specific mentors or conflicts with content-specific mentors	8	12	16
j)	Other assignments within school day	Challenges related to demands on time and energy due to assignment or to additions of teaching beyond science within the school day	6	9	9

k)	Poor facilities	Challenges related to poor facilities (i.e., in which teacher has to move classrooms frequently or are in spaces not conducive to learning science)	8	13	17
l)	School structures	Challenges related to the school structure (or lack thereof) as it relates to policies, staffing levels, and programs	2	7	10

This category relates to contextual issues in which 21 of the 24 participants were coded as having at least one challenge. Some of the participants cited challenges related to a 'lack of local induction supports.' One participant, in discussing the pacing of their formal curriculum, states that it "would be nice to have someone to keep pace with." Another participant expresses a similar concern when they state that, "I do not really have another life science person to work with to try to build an inquiry lesson. I have had 4 different science teachers to work with and I have been there for 4 years."

However, colleagues can also add to the challenges of teaching science as in the case of the 'Curriculum mandates and constraints from staff or school' sub-category. One participant states that the challenge of keeping on the same topic with other science teachers when they state, "schedule is a big deal around here :(Kind of limits you as far as creativity."

Of interest to teaching science are the challenges related to 'poor facilities' and a 'lack of equipment and resources' that may impact the teacher's ability to carry out laboratory instruction. One participant states that they "just move to four different classrooms depending on the period. I just wheel the cart of microscopes along with my cart of other supplies. It keeps me busy and the time goes by so fast." Another beginning teacher states that their classroom is, "not exactly great for science (one sink, no working gas lines, and I have lunchroom tables, not science tables)" highlighting the challenges related to teaching laboratory science with improper, secondary science facilities.

In addition, teachers face challenges related to a lack of materials. The following statement illustrates challenges related to both a classroom management concern ‘Behavior management during activities’ and one related to a lack of materials. They describe that a lab they had wanted to do, “has to happen as a demonstration again because there are not enough materials for everyone, and I don't trust them enough either.” These issues impact instruction and may be a source of dissatisfaction for beginning teachers.

Table 17 *Challenges Related to Classroom Management*

Category	Description	Participants	Sessions	Total
Classroom Management		19	59	215
a) Behavior management during activities	Challenges related to the behavior of students during activities such as laboratories, group activities, and field trips.	7	12	14
b) Cheating	Challenges related to students cheating on tests, activities, and other assignments	3	7	11
c) Developing classroom management rules, procedures, and norms	Challenges related to the development of rules and procedures as a way to improve the learning environment and to mitigate student misbehaviors	8	11	15
d) Efficacy and personal issues related to classroom management	Challenges related to teacher beliefs that they are not effective classroom managers and personal frustrations related to management that impact job satisfaction	8	12	16

e)	Enforcing rules and procedures	Challenges related to teacher enforcement of existing rules and follow-through of consequences in a fair manner	7	17	21
f)	Fostering a respectful classroom environment	Challenges related to developing respectful relations between teacher and student and between other students. Questions on how to help foster a classroom culture of respect	8	12	14
g)	Frustration with disrespect of students	Challenges related to expressed teacher frustration stemming from student disrespect directed at the teacher or their classroom activity	10	14	20
h)	Fun interactions with students are not possible	Challenges related to beliefs that having fun interactions, such as joking with the class, are not possible. Also related to the belief that classroom control may be lost if they do not have a serious persona	3	5	6

i)	Individual student behavior modification	Challenges related to working with changing the behavior of individual students often in one on one situations as well as the exploration of various causes and possible solutions to behavior	7	12	21
j)	Selected students disrupting whole class	Challenges related to individual or small groups of students who are disrupting the learning environment, often resulting in their removal from class	13	26	52
k)	Staff or admin does not support teacher classroom management	Challenges related to staff or administrative policies, decisions, or follow through that undermine the classroom management and disciplinary decisions of the teacher	6	7	10
l)	Theft	Challenges related to the theft of classroom supplies	2	2	2
m)	Whole class off task	Challenges related to management of whole classes of students that are ‘chatty’ or off task	8	12	13

In the category of ‘Classroom Management,’ 19 of the 24 participants were coded with at least one classroom management concern. While it is certainly anticipated that beginning teachers will have classroom management concerns (Adams & Krockover, 1997;Veenman, 1984), it is useful to unpack this category, especially as it relates to science education.

In this category, we see issues related to development of rules and procedures as well as enaction issues related to enforcement of rules and procedures. Within the set of sub-categories related to ‘Developing Classroom Management Rules and Procedures,’ we see queries for help in shaping rules of the classroom. One beginning teacher asks “what are your consequences for flying stuff?” Another teacher states a similar challenge related to the development of rules when he or she states “I want to change their behaviors without punishing the kids who do a great job everyday... and I am running low on strategies.”

Related to the classroom management and procedures codes are a number of challenges connected to ‘Selected students disrupting whole class.’ This comment reflects both challenges related to the development of rules and procedures, and toward fostering a respectful community of learners when he or she states “there is another boy in there that is constantly interrupting and fighting and getting up from his seat and I don't know what else to do with him. He likes to do his assignments in the hall, which is usually okay with me, but it's becoming more of a distraction to send him out because then all the students want to leave too.” Many of these codes reflect management of behaviors, not necessarily the fostering of respectful learning environments or the development of procedures that can help with efficient classroom instruction.

Coupled with this sub-catagory relating to student disruption, are issues related to ‘Efficacy, personal issues related to classroom management,’ and ‘Enforcing rules and procedures.’ One teacher states, “I have a few students who like to push my "niceness" and it's hard for me to [be] tough on them.” Another set of quotes demonstrates issues with efficacy, enforcement, and instruction when one states that “I just need to buckle down on them, but this is the class I feel the least confident in, so it is a lot harder.” Another states that “I don't talk to them about [their disrespect], because I am afraid that I will have to agree that this isn't the best class...” or “but I feel like I don't have the right to, because the class isn't all that great.” This set of quotes relates not only to teacher confidence within classroom management but to their overall confidence with their science instruction.

Of interest to science educators are the special management challenges related to activities in which students move about the classroom such as within laboratory instruction. After a mentor suggests a laboratory activity, the beginning teacher reflects that “my students can be so crazy at times though. It makes me nervous when they're all over the place. I feel like if I turn my head for one second, something happens.” While many of the codes within the ‘Classroom Management’ category take place during seated activities, this category is often coupled with the ‘Cooperative learning’ category in the context of more active forms of instruction, such as laboratory activities.

Other interesting codes relate to beliefs that "Fun interactions with students are not possible" in which their vision of how they would like to interact with students may be in conflict with beliefs about how they can manage the classroom. For example one participant states that, "I think that I am too serious sometimes, but as soon as I let myself relax a little, the kiddos try to go all crazy on me." The other sub-categories of interest relates to 'Fostering a respectful classroom environment.' This code relates to how teachers are actively working to try and promote more positive teacher/student and student/student interactions. One participant states, "I have tried giving out surveys at the beginning of the year to find out these details, but there are so many details and I feel swamped. Then I don't learn anything from them."

Some beginning teachers appear to be working toward a vision of classroom management focused on developing a 'community of learners' (LePage, Darling-Hammond, & Hanife, 2005). From this perspective, it is critical that beginning science teachers foster respectful, relevant learning environments that encourage dialog that is critical to students of science (National Research Council, 1996). However, similar to student academic challenges, many of the codes in this 'Classroom Management' category relate more to what the students are, or are not doing, and how to manage behaviors.

Table 18 *Challenges Related to Issues of General Pedagogical Knowledge*

Category	Description	Participants	Sessions	Total
General Pedagogical Knowledge		23	77	88
a) Assessment policies and procedures	Challenges related to the development and implementation of assessment policies and procedures	10	15	30
b) Cooperative learning	Questions and concerns related to structuring, implementing, and improving group work and cooperative learning activities	9	13	23
c) Daily time management during instruction	Challenges related to pacing within the period and running out of time during the period	4	5	6
d) Fostering discussion and student questioning	Challenges related to facilitating discussions and promoting questions during demonstrations, lectures	3	5	9
e) Fostering student higher order thinking	Challenges related to encouraging student higher order thinking skills related to creativity, problem solving, and curiosity as well as student preference for more passive modes of learning	7	9	10

f)	General concerns about instructional planning and activity creation	Challenges related to a general set of concerns about planning instruction and designing activities	4	6	6
g)	Improve instructions given to students	Challenges related to improving instructions given to students and to having students follow instructions	4	4	4
h)	Integrating other general teaching strategies	Challenges related to teaching strategies not necessarily specific to science	3	4	4
i)	Overwhelmed by grading	Challenges related to the volume of grading or time required for grading	6	7	12
j)	Standardized test preparation	Challenges related to preparing students for standardized tests	2	3	6
k)	Student engagement in general	Challenges related to how to engage students as well as concerns about students who do not engage or are not excited for instruction	11	21	23

l) Want to lecture less	Challenges related BT unease with how much lecture they do done in general	2	3	3
m) Want to do more activities	Challenges related to increasing the amount of activities that are done	7	8	8
Science Pedagogical Knowledge				
n) Assessment (FA AND SA) techniques	Challenges related to the general understanding, development, and implementation of formative and summative assessments techniques	10	16	24
o) Scientific inquiry	Challenges related to the implementation or increases in frequency of inquiry based instruction	4	5	14
p) Technology integration	Challenges related to the integration of technology	2	3	6

The ‘General pedagogical knowledge’ category refers to challenges that do not rise to the level of science specificity. The category ‘General Pedagogical Knowledge’ is placed next to a closely related category ‘General Science Pedagogical Knowledge’ for challenges that rise to the level of general science pedagogy that applies to teaching all disciplines of science, but does not rise to the level of discipline or topic-specificity. These categories within ‘General Science Pedagogical Knowledge’ include ‘Assessment (formative and summative),’ ‘Inquiry based strategies,’ and ‘Technology integration in science.’ Many of these topics may be found in general science pedagogy courses for pre-service teachers.

At times, it becomes a difficult distinction between this category of ‘General Pedagogical Knowledge’ and the closely related category of ‘General Science Pedagogical Knowledge’ as the codes originate in the context of a science specific conversation but at times stay at a level that is general. The following passage highlights the complexity of this distinction. In the passage below, a beginning teacher is describing a post-laboratory activity in a chemistry class:

> certain students will just work on the post lab [alone]...during lab one student will just not do the lab with the other student...sometimes I am unsure because I will see the students working but they have no idea what the other person/persons in the group are doing...and if they did present, sometimes they just don’t say anything or leave it up to the same person over and over again...actually I would like them to present more as small groups instead of the large group discussion...I

really suck at large group discussion cause some of my students are just so quiet or confused or not interested or nervous or all of the above

Within this passage, two codes appear that would be placed in 'General Pedagogical Knowledge' category ('Cooperative Learning' and 'Fostering Student Discussion' sub-codes), however, the conversation is clearly within the context of a science classroom. As in this case, these conversations between beginning teachers and mentors with the same content background and who teach very similar courses at times do not rise to the level of science specificity; in other conversations between mentors and beginning teachers, the level of focus moves between general pedagogical issues to very specific topic issues of pedagogical content knowledge, at times within the same conversation.

Two of the sub-categories within general pedagogical knowledge relate to assessment; 'assessment policies and procedures' and 'overwhelmed by grading.' Within both of these sub-categories, the 'in vivo' codes contain questions on how to assess student learning and the processes by which to grade student work. Many of these sub-categories are technical in nature, however some relate to a vision of their teaching. For example one beginning teacher states that, "I often wonder if my expectations are high enough...Am I asking enough from my students...Pushing them or setting too low of expectations just to get by...." Within the assessment techniques, practical issues such as "how do you pre-assess and then design lessons and have them ready to go the next day?" are posed as well as issues related to general pedagogical knowledge such as how "you know if the students usually have been taught [meiosis] before."

Another set of sub-categories, 'Student engagement,' 'Fostering Higher Order Thinking,' 'Fostering Discussion,' and 'Cooperative learning' relates to interactions with students. 'Student engagement' refers to general challenges when "the students are bored" and discussions on ways to make the instruction more engaging and relevant. Related is the sub-category 'Fostering Student Higher Order Thinking' in which the teachers are concerned that their students will not engage in higher order thinking activities. One participant comments that, "My students are designing their own labs tomorrow to show saturation. I am afraid they will resist using their brains." The sub-category, 'Fostering Discussion and Student Questioning,' in which teachers are seeking ways to engage the students in discussions so they become active participants is somewhat related. One participant comments that, "we had a discussion on [the physiology of] stress and they really wanted a power point instead." Within the 'cooperative learning' sub-category, we see a set of codes related to how to structure and improve group work activities. One participant states "I have a question about making group work/cooperative work more effective...many of my groups (I keep them random) are just falling apart and not working together and I would like them to present their findings to the whole class...suggestions?"

Within 'General Pedagogical Knowledge,' three sub-categories, 'want to lecture less,' 'want to do more labs and activities,' and 'general concerns about instructional planning and activity creation,' relate to challenges in which the beginning teachers are searching for ways to improve their enacted curriculum to include more activities.

Examples of challenges in these areas include one participant's comment, "I think there is always so much you can do, it is hard to narrow down what to do and what not to do" and another states that he or she is are "frustrated by the difficulty of creating active learning activities". This may indicate a conflict between their curricular vision (Darling-Hammond, Banks, Zumwalt, Gomez, Sherin, Griesdorn, & Finn, 2005) and their ability to carry that out. For example, one teacher laments that "I am also struggling with how much I talk in Biology."

Within the 'Science Pedagogical Knowledge' category, the sub-category of 'scientific inquiry' refers to challenges related to understanding and enacting inquiry-based curriculum. For some, the barriers to inquiry relate to the time required, such as the comment that "the biggest stumbling block (to do inquiry) is the volume of content we are expected to cover in the trimester." Another relates to an additional challenge when he or she states that it is "really hard to break the cookbook mode... for both me and [the students] I think."

Table 19 *Science Domain and Topic Level Pedagogical Content Knowledge*

Category	Description	Participants	Sessions	Total
Domain and Topic Level PCK		23	101	279
Formal				
a) Sequencing of topics	Challenges related to creating logical sequences of topic and figuring out what order to teach certain topics	5	8	12
b) Topic selection and depth	Challenges related to what topics should be taught and how in depth they should be taught (i.e., how long)	9	16	27
c) Topics are taking too long	Challenges related to how long a topic took to teach	3	5	6
d) Trying to fit in new topics	Challenges related to running out of time to teach particular topics and the need to 'squeeze' them in	4	7	8
Enacted				
e) Assessment (FA and SA) of particular topics	Challenges related to ways to add and improve existing formative and some summative assessments for	6	7	7

		particular concepts and activities			
f)	Improve the ‘real-world’ relevance of activities and topics	Challenges related to connecting a topic to real world applications that are engaging and relevant to the students lives	5	6	8
g)	Lesson and activity development	Challenges related to the development and possible implementation issues with a particular activity to teach particular concepts	11	21	30
h)	Logistical and technical support with activity	Challenges related to the need for support with more technical and logistical issues with activities (i.e., how activities are done, where materials can be obtained/sampled, and safety concerns with activities)	6	16	25
i)	Need activities and ideas to teach a particular topic	Challenges related to finding activities to teach particular topics. Mainly requests to mentors for activities around specific topics	19	54	76

j)	Not excited about teaching a particular topic	Challenges related to teacher boredom or lack of excitement as it relates to the teaching of specific topics	4	4	4
k)	Setting objectives for a particular topic or activity	Challenges and concerns related to setting or creating objectives for topics and activities	2	4	4
l)	Specific content question within context of activity	Challenges related to understanding a particular concept, usually clarification	4	8	8
m)	Student engagement with a particular topic or activity	Challenges related to student engagement or boredom with particular activities or topics	8	15	20
n)	Student understanding of a topic or specific skill	Challenges related to a lack of student understanding of particular concepts and processes	14	29	40
o)	Teaching controversial topics	Challenges related to navigating controversial topics such as evolution with students	1	2	4

Within 'Science Domain and Topic Pedagogical Content Knowledge' we see codes that are very content-specific; that is the codes are no longer at the general pedagogical knowledge level nor are they at the level of general science pedagogical knowledge. These codes relate to the teaching of science within domains such as Biology and Physics, and in particular, they are codes related to specific topics within a domain, such as atomic theory and DNA extraction.

Many of these challenges could additionally be grouped by challenges related to developing and enacting a 'formal curriculum' and by challenges related to developing and implementing 'enacted curriculum.' Formal curriculum (Darling-Hammond et al., 2005) relates to which topics should be taught, the order in what they should be taught, and to what depth. Within the 'Science Domain and Topic Pedagogical Content Knowledge' categories, we see sub-codes that relate to formal curriculum such as challenges related to 'topic selection and depth' and 'sequencing of topics' as well as the set of challenges related to pacing such as 'topics are taking too long' and 'trying to fit in new topics.' An example of a challenge related to 'topic selection and depth' is when a participant explains that, "I have no idea what I will do for the heredity/genetics unit!!! I have never taught it before and don't know how detailed I should go." This comment also expresses a challenge related to depth. Another participant expresses a similar challenge when they ask if their mentor has, "a lot of material on ecology? There seems to be quite a bit of that in the standards, but I don't know how I will thoroughly cover it. . ." This comment is also an example of a somewhat related code that crosses enacted and formal lines 'need for activities and ideas to teach a particular topic.' In this comment, we can also see an instance of how a beginning teacher is utilizing a content-specific mentor who teaches similar classes.

Enacted curriculum, which refers to daily instructional choices (Darling-Hammond et al., 2005), can encompass the rest of the sub-categories within the 'Science Domain and Topic Pedagogical Content Knowledge.' In these categories we see challenges related to planning for daily instruction and challenges related to implementation. Within the enacted sub-group, we find challenges related to implementation in which students struggle to understand a topic. For example, one participant explains that, "I think that it was confusing for the students to learn about machines when we hadn't talked about work or power yet." This comment also speaks to the formal curricular issue of 'sequencing.' Within another example, a beginning teacher shares particular topic challenges when they explain that their students are struggling to understand balancing reactions as they state that, " I can teach those who get [balancing reactions] easily, but run out of ideas for those not so logical thinkers." Another participant states that, "I think the students are having a lot of difficulty with the DNA topic. It can be complicated and a lot of new words so I am trying to take my time." Content-specific mentoring usually takes place behind these comments as the mentors provide advice or resources or help the beginning teacher to explore these issues in greater depth.

Within this set of science domain and topic level pedagogical content knowledge concerns, there are very few requests for assistance or challenges related to reform-based instruction (i.e., inquiry pedagogies, conceptual change, instruction related to the history and nature of science) beyond limited discussion of student misconceptions. Some mentors who participated in member checking noticed this absence. Challenges related to inquiry-based pedagogy at the topic level are expressed at times in the context of some of the professional development activities the mentor and beginning teacher were participating in on a different area of the site. However, the focus of these professional development activities was incorporating scientific inquiry into the lessons. One comment outside of this activity explores the difficulty of having students to make scientific predictions when they ask, “How do you get them to make predictions? I can only think of basic things like what is it going to look like to the eye, or if it is so small how come we can see it?” This code was placed in the ‘lesson and activity development’ sub-category in which the beginning teachers and their mentors worked to improve the structure of activities.

The sub-category ‘Need activities and ideas to teach a particular topic’ relates to requests for topic-level support from the mentors. Many requests such as,” I was just thinking I don't have a good limiting reagents lab...I'd love to see yours ;o)” are frequent in this section in which the mentors then provide activities via email to the beginning teachers. This may be related to conceptions of mentoring held by both beginning teachers and beginning teachers that the mentor is to act as resource providers[29].

Summary of Challenges

The figure below summarizes the collective set of challenges from this study. Given this set of challenges, it becomes difficult to compare with the existing literature on general challenges teachers face, particularly with Veenman as he does not provide explanations to the list as he feels the list is "fairly self explanatory" (p. 156). This study shows that these challenges are quite complex and at times are difficult to differentiate from one another. In the science education literature on the challenges new science teachers face (see Table 11), we see some similar findings. However, this taxonomy of challenges that new science teachers face provides a more detailed view of the range of the challenges.

In this study we also see factors related to the attrition of beginning STEM teachers cited within prior literature. These issues within the taxonomy that are linked to attrition research include challenges such as inadequate preparation time and large class sizes (Ingersoll & Perda, 2006). These challenges are mostly beyond the scope of induction support. However, experienced and other novice teachers can provide a sense of empathy for these situations[30]. These challenges and additional challenges cited in the attrition literature, such as the limited teacher input into decision making and non-

---

[29] See Barriers chapter

[30] See Affordances chapter

competitive salaries for science educators, must be attended to if we are to stem the rate of attrition (Darling-Hammond & Sato, 2006, Ingersoll & Perda, 2006).

Figure 1 Taxonomy of Beginning Science Teacher Challenges

General Pedagogical Knowledge	Science Pedagogical Content Knowledge (Domain and Topic Level)	Classroom Management	Context of School or District
a) Assessment policies and procedures b) Cooperative learning c) Daily time management during instruction d) Fostering discussion and student questioning e) Fostering student higher order thinking f) General concerns about instructional planning and activity creation g) Improve instructions given to students h) Integrating other general teaching strategies i) Overwhelmed by grading j) Standardized test prep k) Student engagement in general l) Want to lecture less m) Want to do more activities Science Pedagogical Knowledge n) Assessment (FA AND SA) techniques o) Scientific inquiry p) Technology integration	*Formal* a) Sequencing of topics b) Topic selection and depth c) Topics are taking too long d) Trying to fit in new topics *Enacted* e) Assessment (FA and SA) of particular topics f) Improving the real-world relevance of activities and topics g) Lesson and activity development h) Logistical and technical support with activity i) Need activities and ideas to teach a particular topic j) Not excited about teaching a particular topic k) Setting objectives for a particular topic or activity l) Specific content question within context of activity m) Student engagement with a particular topic or activity n) Student understanding of a topic or specific skill o) Teaching of controversial topics	a) Behavior management during activities b) Cheating c) Developing classroom management rules, procedures, and norms d) Efficacy and personal issues related to classroom management e) Enforcing rules and procedures f) Fostering a respectful classroom environment g) Frustration with disrespect of students h) Fun interactions with students are not possible i) Individual student behavior modification j) Selected students disrupting whole class k) Staff or admin does not support teacher classroom management l) Theft m) Whole class off task	a) Class length too short b) Class size too big c) Concerns about student population d) Curriculum mandates and constraints from staff or school e) Issues with administration f) Issues with district g) Issues with staff h) Lack of equipment and resources i) Lack of local induction supports j) Other assignments within school day k) Poor facilities l) School structures

External a) Finding new employment b) Lacking support from partner c) Masters coursework d) Voluntary extracurricular	Diverse Learners a) ELL/SLC Students b) Special education students c) Students with psychological challenges	Student Academic a) Student effort related to improving personal understanding b) Students failing courses c) Student effort related to completing assignments and other tasks d) Students performance on formal assessments e) Working with parents on student academic issues	Personal Beliefs, Attitudes, and Concerns a) Concern about a general lack of content knowledge b) General frustration with profession c) Lack of time and energy to be effective d) Mental health issue impacting teaching e) Preference for different age group f) Self described challenges of being a new teacher g) Self efficacy (not classroom management related)

Implications

As one looks across the set of challenges one may begin to wonder how unique these challenges are to the teaching of science. In many ways, these challenges may be similar to those of a beginning teacher in a high school statistics classroom or a beginning teacher in a middle school world history classroom. Certainly there are issues related to general pedagogical knowledge, discipline pedagogical knowledge, and domain and topic level pedagogical content knowledge issues for teachers across all domains of teaching.

However, the question this paper additionally explores is the value or potential for content-specific support. For example, in looking across the taxonomy, one wonders where beginning physics teachers may receive support, especially instructional support, for challenges related to particular topics they teach. Could an experienced English teacher, who is a well-prepared mentor, support the range of challenges a beginning physics teacher may face without a deep background in physics pedagogical content knowledge?

In many models of induction, even more comprehensive models such as models promoted by the New Teacher Center (The New Teacher Center, 2007), the role of content-specific support is not addressed. In some induction models, there may be a full release mentor with a general set of facilitation skills, who may not be teaching in the same grade band, supporting multiple beginning teachers in multiple domains. There may be value in their work, particularly as they help to facilitate teacher thinking, but the range of challenges for which they may need to provide direct instructional support may be difficult for a mentoring generalist. A content-specific mentor who provides support through face-to-face interaction or through distance technologies, in concert with other sustained professional development supports, may help the beginning teacher navigate these challenges.

For example, if a beginning, in-field biology teacher is preparing to craft instruction around a topic such as DNA sequencing, biology mentors may provide a facilitated discussion around this complex topic to help the beginning teacher explore what should be taught, in which sequence should it be taught, and in what depth. They also play a role in pushing the beginning teacher to focus their thinking on the needs of individual students in the planning of instruction that attends to students' prior knowledge and engages them with ideas that are relevant not to the broader real world, but to their own lives within the context of this specific content.

With regard to the challenges outside of the 'Domain and Topic Level PCK,' content-specific mentors may also be best poised to support teacher learning in areas such as classroom management and student academic issues. Even though conversations noted in this study at times did not rise to the level of science specificity, these issues can be supported through a domain and topic-specific lens. Mentors can play a critical role in helping to reframe and analyze practice "from different perspectives or by shifting beginning teachers' attention" (Wang, Odell, & Schwill, 2008).

Much like a compound microscope with different objective lenses, a mentor and beginning teacher may examine an instructional challenge with different 'lenses of power.' They may explore the challenge and the related teacher knowledge at a general level that includes general knowledge (pedagogical knowledge, content knowledge, and knowledge of student learning), a science pedagogical level, a science domain pedagogical content knowledge level, and a topic-specific pedagogical content knowledge level depending on the situation and level of teacher knowledge within each level.

Using this framework, challenges related to classroom management, diverse learners, student academic issues, and the many specific issues of enactment could looked at in a broad field of view using a 'low power'. For example, the challenges within classroom management all take place in the context of a science classroom and within the context of a particular activity. It may be useful for the mentor and beginning teacher to address issues of classroom management through a more holistic lens of the relationships between the instruction, the behaviors, and the learning environment of the classroom, directed toward promoting a relevant, respectful learning environment that encourages dialog that represents scientific communication as a component of the nature of science (National Research Council, 1996).

Within this level of analysis, a particular classroom management challenge related to a disruptive student could be re-contextualized, re-integrated, and re-analyzed at a level in which the whole context of the classroom ecosystem in which learner, instructor, activity, topic, and peers all play a role in shaping student learning. By increasing magnification, the beginning teacher and mentor could begin focus on particular relationships between the student, context, content, and instructor. They could ultimately move to a level of analysis that is focused tightly on a particular aspect of the instruction, the context, the content, or the student.

As in the case of a compound microscope, there is danger when mentors and beginning teacher focus their attention at the highest level of power. In this level of analysis, the beginning teachers may seek and/or the mentors may provide immediate advice or resources to help mitigate a challenge. This immediate assistance may not help to address potential gaps in teacher pedagogical knowledge, content knowledge, knowledge of student learning, or associated beliefs that may be not be congruent with the science education communities' vision of reform-based practice. Well-prepared content-specific mentors could help the beginning teacher to identify gaps in knowledge and levels of expertise throughout the many dimensions of teaching science (Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee, 2002) as well as help enact the reforms called for by the community (Koballa

& Bradbury, 2009). This vision of mentoring, as one component on content-specific induction, may help to improve teacher expertise as well as help toward retention.

This taxonomy of science teacher challenges could be used to inform professional development supports within comprehensive induction programs to provide targeted, relevant professional development. For example, conversations between beginning teachers and their mentors could use this taxonomy to identify challenges they are currently facing. Using their set of challenges, they could then explore standards for teaching science (Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee., 2002) to identify areas of expertise that the beginning teacher may wish to focus professional development. Sustained professional development activities aligned to standards, and to the challenges these teachers face, could be used to design targeted learning experiences linked to practice that improves teacher knowledge of the standard while working to impact practice. These professional development activities could be done with peers who are facing similar challenges.

Future research may wish to explore how these challenges change as a function of time among other variables such as preparation, context, and licensure. Additional research could explore how mentors respond to the challenges that the beginning teachers cite through various levels of support and could explore what role the depth of mentor pedagogical content knowledge plays in supporting beginning teacher development of pedagogical content knowledge. Additional research may also be needed to explore the frequency of certain challenges and to explore why expected challenges, such as issues related to the history and nature of science, do not appear in the language of the beginning teachers and mentors.

Finally, analysis of this taxonomy may lead to broader questions of practice in regards to science teacher preparation. For example, what do these challenges say to us as science teacher educators? What may we do to better prepare our beginning teachers towards mitigating some of these challenges before they enter professional practice? What can we do to prepare them better to navigate contextual challenges in their first years of practice?

This study suggests that there is a vast range of challenges that beginning science teachers can face. Additionally, it suggests that content-specific induction, with mentoring at its core, can help beginning teachers explore many of these challenges. We, as members and stakeholders of the science education community, must help our beginning teachers to improve their knowledge and to help navigate these challenges through the process of induction. We have a moral duty to help induct these beginning teachers into the profession while supporting them during these tenuous times of development. Comprehensive, systemic, content-specific induction may ultimately improve practice, stem retention caused by job dissatisfaction, and most importantly improve student science literacy needed to address the challenges and opportunities of the 21^{st} century.

Chapter 5: Toward a Vision of a Different Induction Experience for Beginning Science Teachers

Introduction

This final section integrates knowledge gained from the 'affordances,' 'barriers', and particularly within the 'challenges' study to argue for a new vision of the induction experience supported by online communities of practice. It first explores and questions the levels of responsibility for curricular development placed on beginning teachers through a different lens on the taxonomy of challenges. It concludes with a new vision for online induction systems by which the science education community develops and supports beginning teachers' curricular needs.

The 'challenges study' explores the range of challenges that beginning science teachers may face. It makes an argument for content-specific support through mentoring and other professional development activities that support the unique challenges of learning to teach science. However, even with comprehensive, systemic induction programs that account for these challenges we still may be asking too much of our beginning teachers and our mentors, particularly as it relates to the development of formal and enacted curriculum.[31] When we examine the overall volume of requests

[31] See Challenges study for discussion on formal and enacted curriculum (Darling-Hammond, Banks, Gomez, Sherin, Griesdorn, & Finn, 2005)

within the ‘challenges’ study for assistance with formal and enacted curriculum we must pause to ask why this range of codes is so vast and frequent.

While the ‘challenges’ study provides a taxonomy of challenges instead of a list of challenges ranked by frequency, the frequency of some codes within this study is worth additional analysis. For example, codes within the ‘Domain and Topic Level PCK’ are expressed by 23 out of the 24 participants (95%), occur in 101 out of the 165 conversations analyzed (61%), and account for 279 out of the 834 overall codes (33%) making it the most frequently coded category. Within this category, the sub-category of ‘need activities and ideas to teach a particular topic’ is expressed by 19 out of the 24 participants (79%), occur in 54 out of the 165 conversations (33%), and account for 76 of the 834 codes (9%) making it the most frequently coded sub-category. These patterns provoke the following question: Why are beginning science teachers asking for help with curricular development from their mentors?

As the ‘Barriers’ study suggests, the mentors within this online induction program, were the most valued support. The ‘Affordances’ study also suggests that mentors afforded access to curricular materials. This echoes literature that supports that mentors are the most common form of induction support (Smith & Ingersoll, 2004) and often provide access to curriculum (Barab, MaKinster, & Scheckler, 2003; Britton & Raizen, 2003; Wang, Odell, & Schwill, 2008), to meet the immediate needs of these beginning teachers.

Yet, literature also suggests caution in over-reliance on mentors as it is difficult for one person to support the multitude of needs of a beginning teacher (Britton & Raizen, 2003). The literature also suggests caution that mentors may promote and reinforce practices that are not consistent with the educational communities' visions of practice (Feiman-Nemser, 2001). This prompts a secondary set of questions: What kinds of resources and what quality of resources are they receiving from their mentors when the beginning science teachers ask for assistance? How do these resources compare to the communities vision of reform-based curriculum? Do these resources impact their pedagogical knowledge and/or pedagogical content knowledge? How do these beginning teachers use these resources? Are they adapted for their own classroom use?

Before exploring this secondary set of questions, we must return to the primary question as to why they are asking for curricular help from their mentors. Returning to the taxonomy, let us first examine the challenges within domain and topic pedagogical content knowledge that are related to developing formal and enacted curriculum and turn the lens toward the science education community. We must ask ourselves, as teacher educators, mentors, and others within this science education community of practice, if it is our own expectations on these beginning teachers that may be partially responsible for some of the challenges they face? Could we be responsible for the conflicts or disconnects between teachers' visions of practice[32] and their actual practices (Bradford & Dana, 1996; Roehrig & Luft, 2004; Simmons, 1999; Sweeney, Bula, & Cornett, 2001)?

To begin this exploration as to why beginning teachers are asking for help and what role we may play in this, let us first examine current practices as suggested by what a well-prepared science educator should know and be able to do (Darling-Hammond & Bransford, 2005; Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee, 2002) by creating a 'model' profile of a beginning physics educator ready to enter into her first days of professional practice.

To do so, let us make a few assumptions about this 'model' beginning science teacher's knowledge base. We will assume that this teacher has a strong vision of practice that is consistent with goals of the science education community, such as those outlined within the National Science Education Standards (National Research Council, 1996). This teacher has solid content knowledge that includes deep understanding of their discipline's science content, processes, history, and interactions with other knowledge domains and society. They have a strong science pedagogical knowledge base and understands of the goals and purposes of various pedagogies of inquiry based science and of conceptual change and has a set of tools to enact these pedagogies. They have understandings of curricular sequencing as it relates to formal curricular development. This 'model' beginning science teacher also has dispositions and skills of a reflective

[32] If indeed they have an articulated vision of practice

practitioner that help them to learn in and from practice. They also has beliefs consistent that all can learn science and knowledge of how students learn science.

Let us also make a few assumptions about their first year teaching assignment. This ‘model’ beginning teacher has a reasonable number of preparation periods, teaches in a classroom that is conducive to teaching physics, and has a wealth of laboratory resources and supplies, and participates within a content-specific induction program with a comprehensive set of supports. For now, we will ignore the contextual challenges, personal beliefs and attitudes, classroom management, and student academic issues that they may face as outlined within the ‘challenges’ study, but we can assume they are poised assume the same responsibilities of their veteran peers.

We now ask this first year teacher, on day one, to implement a formal curriculum that contains a coherent scope and sequence of instruction that attends to local, state, and national standards. This formal curriculum details topics and concepts to teach. It may be argued that beginning teachers are provided with this formal curriculum ether through textbooks or through local guidance, however within the ‘challenges’ data, the frequency and range of challenges suggests that beginning teachers either are provided with formal curriculum and choose not to follow, or they are not provided with a formal curriculum at all.

This first year teacher must also design an enacted curriculum that includes lessons for each day of instruction. Again, it may be argued that teachers are provided a daily curriculum through scripted lessons within a textbook or curricular package. However the data from ‘challenges’ study suggests that many of these beginning teachers seek help in (re)developing enacted curriculum and more frequently seek curricular resources from their mentor. This again suggests that if these beginning teachers are provided with an enacted curriculum, that they may not be fully using it.

Even if these beginning teachers are provided formal and enacted curriculum that is consistent with the science education communities vision of instruction, Darling-Hammond, Banks, Zumwalt, Gomez, Sherin, Griesdorn, and Finn (2005) caution us toward thinking that there exists a ‘teacher-proof’ curriculum:

> Although teachers may or may not be working with a formal curriculum approach, framework, or set of materials outlined by a state or district, these resources, no matter how useful, cannot determine all that a teacher does. Curricular materials alone do not determine how the teacher can create equitable classrooms that support all students, draw connections to students’ prior knowledge and experiences, choose appropriate starting places and sequences of activities, develop assignments and assessments to inform learning and guide future teaching, and construct scaffolding for different students based on their needs. (p. 176)

Many beginning teachers may have had little experience in attending to the above activities within this vision of teaching. During student teaching, we may assume that these beginning teachers use much of the formal and enacted curriculum of their cooperating teacher and are not the instructional leader of the classroom. We then expect them carry out this vision of an instructional leader, ready to implement the formal and day-to-day enacted curriculum that incorporates practices that are congruent with the science education community's vision of instruction (National Research Council, 1996) on the very first day of their practice.

Using this line of reasoning, we may look at the frequency of challenges related to the 'limited time and energy' or self-effacing comments related to 'self described challenges of learning to teach' with a different light. This vision of teacher may be difficult to attain for many beginning science teachers, let alone many experienced teachers. When we layer back on the potential taxonomy of challenges that this 'model' beginning teacher may face, such as classroom management, student academic struggles, contextual issues, personal beliefs, we may be concerned as to what we expect from these beginning teachers, especially as it relates to the development of formal and enacted curriculum. If these beginning teachers are striving to design, or re-design, their formal and enacted curricula while attending to the visions mentioned above, as well as the many potential challenges, it may be no wonder they make such comments related to limited time and energy. We cannot prepare our beginning teachers to be agents of change or as the leaders of reform (Davis, Petish, & Smithey, 2006) without more support, especially as it relates to curriculum.

From the ‘challenges study,’ we cannot assume that teachers have a palette of reform-based materials available from which to blend, sequence, and adapt for their own use. We see glimpses of the tension and potential frustration that this ‘responsibility through autonomy’ may create. Some beginning teachers are, “frustrated by [the] difficulty of creating active learning activities” or state that, “it is so hard to come up with meaningful activities for my students to do just so they aren't stuck in their desks” or at times feel that, “there are days when I struggle to come up with things to teach for all 3 classes.” One beginning teacher, when receiving materials expresses a desire for additional curricular materials and ideas they can use within their classroom when they state that “man you have some great ideas, where do you get all this stuff? I can surf the internet for hours and not come up with the cool ideas you've given me. We definitely need to keep in touch.” Within the sub-category of ‘Need activities and ideas to teach a particular topic’ many of the activities they seek are often laboratory in nature. [33]

Again, there is danger in asking the mentor to be the primary provider of curriculum to meet the beginning teacher’s needs as the resources they provide may not be consistent with current visions of practices within science. In addition, there may be

[33] Additional research suggests (Moore & Boyoung, 2007) that beginning teachers often seek resources through internet search engines such as Google often without assessing the quality of the materials or the sources.

danger in sharing activities that may have worked well for their context, but may not be suited for the beginning teacher's context.

We must be deeply concerned that teachers within this period of induction are at perhaps their most critical stage within their development. Gold suggests that, "few experiences in life have such a tremendous impact on the personal and professional life of a teacher as does the first year of teaching." Even if we move beyond sink-or-swim or Robinson Crusoe models (Lortie, 1966) towards comprehensive induction systems, the demands placed on beginning teachers by our expectations on the levels of curricular development may amount to providing little more than a small, floating seat cushion.[34] We may do a deep disservice to our 'model teacher' and to the profession when we, as science teacher educators, help to instill a professional vision of a teacher as a curricular leader, arm them with pedagogical tools to carry out the reform-based pedagogy to instantly face the constraints of time and energy due to the enormous challenge of preparing reform-based curricula.

Curricular Engineers and Community-Based Repositories

We need a different vision for the development and induction of beginning science teachers that shifts responsibly for developing or re-designing curriculum away

[34] Although professional practice school models can carefully scaffold the teacher into practice through well integrated experiences.

from the beginning teacher. Within this vision, the responsibility for assistance with formal and enacted curricular development is placed on the larger science education community of practice, yet we retain the vision of teacher as instructional leader. This is a shift that changes the focus of the teacher from instructional designer toward instructional engineer.

We must provide our beginning teachers formal and enacted curricular materials that have been created and vetted from within the science education community of practice to carry out this role of engineer. This community-developed curriculum should not prescribe what is taught and how it is taught, but provide the beginning teacher with a palette of vetted reform-based activities that can be used to assemble a formal and enacted curriculum to meet the needs of their particular students. This community developed and driven 'repository' could include such components as a common set of alternative conceptions and suggestions for real-world relevance for each topic, suggestions on formative and summative assessment for each topic, and activities such as discrepant events, laboratories, and projects for each topic. This community could have tools that allow them to select, sequence, and adapt these curricular resources to form a formal and enacted curriculum. One could imagine it as a repository of science pedagogical content knowledge for common topics within each discipline. The use of information technology could be leveraged to create this community-driven, knowledge base designed with the pre-service teacher, beginning teacher, and even the experienced in-service teacher in mind. This community repository can also provide resources and research that helps to make public the community's pedagogical practices. In essence this vision calls for a repository for science pedagogical knowledge.

This community-driven repository must move beyond a simple set of collected activities, as called for to support induction efforts (National Commission on Teaching and America's Future, 2009) and in-service teacher efforts (The National Commission on Mathematics and Science Teaching for the 21st Century, 2001) toward an interactive and evolving community knowledge base.[35] These well-scaffolded resources will help shift the role of the beginning teacher from designer (or re-designer) of curricula to that of an engineer who utilizes and applies the knowledge base in novel ways to meet the needs of their classroom.

The role of the mentor becomes that of a guide within the community to help the beginning teacher select and adapt formal and enacted components, to help with issues of implementation, to assist with reflection on practice through activities such as student work analysis, and to improve teacher knowledge and practices. The mentor can also provide formative feedback on the curriculum adoption and feedback on implementation. The mentor and beginning teacher can also give back to the community by improving the

[35] I envision building and researching this community as a larger component of my research agenda around science teacher induction.

components of a lesson, or developing occasional activities, and sharing them back to the community repository. The act of 'engineering' or 'arranging' formal and enacted curriculum through this environment provides an opportunity for professional development.

Within this vision, the mentor still provides support with the central tasks of learning to teach and still supports many of the challenges beginning teachers face. They continue to help provide emotional support and encouragement and provide guidance on activities that help meet the challenges that the individual teacher may face.

This repository could also contain the professional development activities aligned with professional teaching standards and the taxonomy of challenges as suggested within the 'challenges study.' Mentors and beginning teachers could use the interaction within the community repository to simultaneously 'build' curriculum, while focusing on a particular challenge, such as student motivation, throughout the process of development, enaction, and reflection. The building of curriculum serves dual purposes for instruction and professional development.

The pre-service experience may also change to prepare the teacher to become a curricular engineer through interaction with this community repository. Within pre-service preparation, beginning teachers could explore the environment through scaffolded activities in which they select, adapt, and perhaps create resources for use in field experiences, perhaps within professional practice schools, with the help of a mentor. The key would be to help prepare this teacher to utilize this community resource for their first day of professional practice and would work to bridge the gap between preparation and practice.

We face a tremendous opportunity, both moral and pragmatic. We must help meet the individual needs of beginning teachers with the purposes of providing emotional and technical support, while helping them grow professionally. Content-specific mentoring and other content-specific supports are a wonderful start; however, we must also challenge our notions of what we expect of our beginning teachers. We must also work to create supports that off-load responsibility on the mentor and beginning teacher with regard to the enormous time and energy required to create or redesign reform-based curriculum. Through the development of a community driven curricular repository that can be used within pre-service education and within induction we can meld "theory and practice, doing and reflection, the individual and community, in a manner that transforms all components" (Barab, Barnett, & Squire, 2002, p. 530), to help beginning science teachers both thrive and survive and improve science education for all.

Bibliography

Abell, S. (2007). Research on Science Teacher Knowledge. In S. Abell, & N. Lederman, *Handbook of Research on Science Education* (pp. 1105-1150). Mahwah, NJ: Lawrence Erlbaum Associates.

Achinstein, B., & Athanases, S. Z. (2006). *Mentors in the making: Developing new leaders for new teachers.* New York, NY: Teachers College Press.

Adams, P. E., & Krockover, G. H. (1997). Concerns and perceptions of beginning secondary science and mathematics teachers. *Science Education,* 81(1), 29-50.

Alliance for Excellent Education. (2005). *Teacher attrition: A costly loss to the nation and to the states.(Issue Brief).* Washington, DC: Alliance for Excellent Education.

Augustine, N. R. (2005). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academy Press.

Babinski, L., Jones, B., & DeWert, M. (2001). The Roles of Facilitators and Peers in an Online Support Community for First Year Teachers. *Journal of Educational and Psychological Consultation*, 12(2) 151-169.

Barab, S. A., Barnett, M., & Squire, K. (2002). Developing an empirical account of a community of practice: Characterizing the essential tensions. *Journal of the Learning Sciences,* 11(4), 489-542.

Barab, S. A., MaKinster, J. G., & Scheckler, R. (2003). Designing system dualities: Characterizing a web-supported professional development community. *Information Society, 19*(3), 237.

Behrstock, E., & Clifford, M. (2009). *Leading Gen Y Teachers: Emerging Stratagies for School Leaders.* Washington, DC: National Comprehensive Center for Teacher Quality.

Bianchini, J. A., Johnston, C. C., Oram, S. Y., & Cavazos, L. M. (2003). Learning to teach science in contemporary and equitable ways: The successes and struggles of first-year science teachers. *Science Education*, 87(3), 419-443.

Bice, L. (2005). *The construction of knowledge about teaching practice and educating students from diverse cultures in an online induction program*. Unpublished doctoral dissertation, Montana State University, 2005.

Bradford, C., & Dana, T. (1996). Exploring science teacher metaphorical thinking: A case study of a high school science teacher. *Journal of Science Teacher Education, 7*(3), 197-221.

Brady, L., & Schuck, S. (2005). Online mentoring for the induction of beginning teachers. *Journal of Educational Enquiry*, 6(1), 65-75.

Bransford, J., Darling-Hammond, L., & LePage, P. (2005). Introduction. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing world: What* *teachers should know and be able to do* (pp. 1-39). San Francisco, CA: Jossey-Bass

Brickner, D. (1995). *The effects of first and second order barriers to change on the degree and nature of computer usage of secondary mathematics teachers: A case study*. Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Britton, E. (2009). Induction Programs and Begining Science Teachers. In A. Collins & N. Gillespie (Eds.), *The continuum of secondary science teacher preparation: Knowledge, questions, and research recommendations* (pp. 159-170). Rotterdam: Sense Publishing.

Britton, E., & Raizen, S. (2003). Comprehensive teacher education induction in five countries: Implications for supporting U.S. science teachers. In J. Rhoton, & P. Bowers (Eds.), *Science Teacher Retention: Mentoring and Renewal. Issues in Science Education* (pp. 13-21). Arlington, VA: NSTA Press.

Britton, E., Paine, L., Pimm, D., & Raizen, S. (2003). *Comprehensive teacher induction: Systems for early career learning*. Boston, MA: Kluwer Academic

Cajete, G. (2009, March 10). “Re-creating Sustainable Indigenous Communities in an Environmentally Compromised 21st Century.” Speech presented for the North Star STEM Alliance Reception and Feast, North Star STEM Alliance, University of Minnesota, St. Paul.

Collison, G., Elbaum, B., Haavind, S., & Tinker, R. (2000). *Facilitating online learning: Effective strategies for moderators.* Madision, WI: Atwood Publishing.

Darling-Hammond. (2006). *Powerful Teacher Education.* San Francisco, CA: Jossey-Bass.

Darling-Hammond, G., Banks, J. Z., Zumwalt, K., Gomez, L., Sherin, M. G., Griesdorn, J., & Finn, L. (2005). Educational goals and purposes: Developing a curricular vision for teaching. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should know and be able to do* (pp. 169-200). San Francisco: Jossey-Bass.

Darling-Hammond, L., & Bransford, J. (2005). *Preparing teachers for a changing world: What teachers should know and be able to do.* San Fransico: Jossey-Bass.

Darling-Hammmond, L., & Richardson, N. (2009). Research review / Teacher learning: What matters? *Educational Leadership*, 66(5) 46-53.

Darling-Hammond, L., & Sato, M. (2006). Keeping good science teachers: What science leaders can do. In J. Rhoton, & P. Shane (Eds.), *Teaching science in the 21st century* (pp. 177-196). Arlington, Va.: NSTA Press.

Darling-Hammond, L., Wie, R., Andree, A., Richardson, N. & Stelios, O. (2009). *Professional learning in the learning profession*. Washington, DC: National Staff Development Council

Davis, E., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research, 76*(4), 607-651.

DeWert, M., Babinski, L., & Jones, B. (2003). Safe passages: Providing online support to beginning teachers. *Journal of Teacher Education*, 54(4) 311-320.

Doering, A., Miller, C., & Veletsianos, G. (2008). Adventure learning: Educational, social, and technological affordances for collaborative hybrid distance education. *Quarterly Review of Distance Education,* 9 (3), 249-266.

Eick, C. J. (2002). Job sharing their first year: A narrative of two partnered teachers' induction into middle school science teaching. *Teaching and Teacher Education, 18* (7), 887-904.

Ertmer, P. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development*, 47(4), 47-61.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record*, 103, 1013-1055.

Fulton, K., Yoon, C., & Lee, C. (2005). *Induction into Learning Communities.* Washington, DC: National Commission on Teaching and America's Future.

Gareis, C., & Nussbaum-Beach, S. (2007). Electronically mentoring to develop accomplished professional teachers. *Journal of Personnel Evaluation in Education*, 20(3-4), 227-246.

Gaver, W. (1991). Technology affordances. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: Reaching Through Technology*. New Orleans.

Gentry, L., Denton, C., & Kurz, T. (2008). Technologically-based mentoring provided to teachers: A synthesis of the literature. *Journal of Technology and Teacher Education*, 16(3), 339-373.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of grounded heory: Strategies for qualitative research.* Chicago, IL: Aldine Publishing Company.

Gold, Y. (1996). Beginning teacher support. Attrition, mentoring, and induction. In J. Sikula (Eds.), *Handbook of research on teacher education* (pp. 548-594). New York, London: Macmillan.

Gordon, S. P. (1991). *How to help beginning teachers succeed.* Alexandria: Association for Supervision and Curriculum Development.

Grimbrug, B. (2006, April). *The structure of teacher's online discours*es. Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Grossman, P. (1990). *The Making of a Teacher.* New York, NY: Teachers College Press.

Hammerness, K. D.-H., & Bransford, J. (2005). How teachers learn and develop. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing* *world : What teachers should learn and be able to do* (pp. 358-389). San Francisco, CA: Jossey-Bass.

Hawkes, M., & Romiszowski, A. (2001). Examining the reflective outcomes of asynchronous computer-mediated communication on inservice teacher development. *Journal of Technology and Teacher Education*, 9(2), 283-306.

Herrington, A., Herrington, J., Kervin, L., & Ferry, B. (2006). The design of an online community of practice for beginning teachers. *Contemporary Issues in Technology and Teacher Education, 6*(1), 120-132.

Huling-Austin, L. (1992). Research on learning to teach: Implications for teacher induction and mentoring programs. *Journal of Teacher Education,* 43(3), 173-180.

Ingersoll, R. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American Educational Research Journal,* 38(3), 499-534.

Ingersoll, R. (2003). Turnover and shortages among science and mathematics teachers in the United States. In J. Rhoton, & P. Bowers (Eds.), *Science teacher retention* (pp. 1-12). Arlington, VA: NSTA Press.

Ingersoll, R. & Perda, D. (2006). *What the data tell us about shortages of mathematics and science teachers.* Paper presented at the NCTAF Symposium on the Scope and Consequences of K12 Science and Mathematics Teacher Turnover, Racine, WI, October, 2006.

Interstate New Teacher Assessment and Support Consortium, Science Standards Drafting Committee (2002). *Model standards in science for beginning teacher licensing and development: A resource for state dialogue.* Washington: Council of Chief State School Officers.

Jaffe, R., Moir, E., Swanson, E., & Wheeler, G. (2006). EMentoring for student success. In C. Dede (Ed.), *Online professoinal development for teachers: Emerging models and methods* (pp. 89-116). Cambridge: Havard Education Press.

Kahle, J. B., & Kronebusch, M. (2003). Science teacher education: From a fractured system to a seamless continuum. *Review of Policy Research*, 20(4), 585-602.

Kirschner, P., Strijbos, J., Kreijn, K., & Jelle Beers, P. (2004). Designing electronic collaborative learning environments. *Educational Technology Research and Development*, 52(3), 44-66.

Koballa, T., & Bradbury, L. (2009). Mentoring in support of science teaching. In A. Collins, & N. Gillespie (Eds.), *The continuum of secondary science teacher preparation: Knowledge, questions, and research recommendations* (pp. 171-187). Rotterdam: Sense Publishing.

Lampert, M. (1985). How do teachers manage to teach? Perspectives on problems in practice. *Harvard Educational Review, 55*, 178-194.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

LePage, P., Darlling-Hammond, L., & Hanife, A. (2005). Classroom management. In L. Darling-Hammond, & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should know and be able to do.* (pp. 327-357). San Fransico, CA: Josey Bass .

Lortie, D. (1966). Teacher socialization: The robinson crusoe model. *The Real World of the Beginning Teacher* (pp. 54-66). Washington: National Commission on Teacher Education and Professional Standards.

Lortie, D. (2002). *Schoolteacher: A sociological study.* Chicago: University of Chicago Press.

Loughran, J. (1994). Bridging the gap: An analysis of the needs of second-year science teachers. *Science Education , 78* (4), 365-386.

Luft, J. (2003). Induction programs for science teachers: What the research says. In J. Rhoton, & P. Bowers, *Science Teacher Retention: Mentoring and Renewal. Issues in Science Education* (pp. 34-45). Arlington: NSTA Press.

Luft, J., Roehrig, G., & Patterson, N. (2003). Contrasting landscapes: A comparison of the impact of different induction programs on beginning secondary science teachers' practices, beliefs, and experiences. *Teaching and Teacher Education,* 40(1), 77-97.

Marzano, R., Pickering, D., & Pollock, J. (2001). *Classroom instruction that works: Research-based strategies for increasing student achievement.* Alexandria: Association for Supervision and Curriculum Development.

McAleer, D (2006, April). *Coding dialogue at the individual post level in the content oriented discussion areas in an online mentoring program.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Merseth, K. (1991). Supporting beginning teachers with computer networks. *Journal of Teacher Education*, 42(2), 140-147.

Miles, M., & Huberman, M. (1994). *Qualitative data analysis: An expanded sourcebook.* Bevelry Hills: Sage.

Moore, J., & Boyoung, C. (2007). Beginning teachers' use of online resources and communites. *Technology, Pedagogy, and Education*, *16*(2), 215-224.

National Comission on Teaching and America's Future. (2009). *Learning teams: Creating what's next.* Washington, DC: National Comission on Teaching and America's Future.

National Commission on Teaching and America's Future. (2009, March 2). *NCTAF, Pearson partner to launch pioneering online communities*. Retrieved April 22, 2009, from National Commission on Teaching and America's Future: http://www.nctaf.org/resources/news/press_releases/PearsonTLINC.htm

National Research Council. (1996). *National science education standards*. Washington, DC: National Research Council.

National Science Board. (2008). *Science and engineering indicators.* Washington, DC: National Science Foundation.

Roehrig, G., & Luft, J. (2004). Constraints experienced by beginning secondary science teachers in implementing scientific inquiry Lessons. *International Journal of Science Education, 23,* 3-24.

Roehrig, G., & Luft, J. (2006). Does one size fit all? the induction experience of beginning science teachers from different teacher-preparation programs. *Journal of Research in Science Teaching, 43* (9), 963-985.

Romano, M. (2008). Online discussion as a potential professional development tool for first-year teachers. *Technology, Pedagogy, and Education*, 17(1), 53-65.

Schlager, M., & Fusco, J. (2003). Teacher professional development, technology, and communities of practice: Are we putting the cart before the horse? *Information Society,* 13(3), 203-220.

Shuck, S. (2003). Getting help from the outside: Developing a support network for beginning teachers. *Journal of Educational Enquiry,* 4(1), 49-67.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Simmons, P. E. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching*, 36(8), 930-954.

Smith, T., & Ingersoll, R. (2004). What are the effects of induction and mentoring on beginning teacher turnover? *American Educational Research Journal, 41*(3), 681-714.

Sweeney, A. E., Bula, O., & Cornett, J. (2001). The role of personal practice theories in the professional development of a beginning high school chemistry teacher. *Journal of Research in Science Teaching*, 38(4), 408-441.

Taylor, P. & Mike, A. (2006). *An examination of the effect of facilitation training on the improvement of dialogue quality in the electronic mentoring for student success program: addendum- another year of analysis.* Paper presented at the meeting of the National Association for Research in Science Teaching, San Francisco, CA.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8.

The National Commission on Mathematics and Science Teaching for the 21st Century. (2001). *Before it's too late: A report to the nation.* Washington: The National Commission on Mathematics and Science Teaching for the 21st Century .

The New Teacher Center. (2007). *Induction institute*. Retrieved 4 31, 2009, from http://www.newteachercenter.org/induction_institute.php

Veal, W., & MaKinster, J. (1999). Pedagogical content knowledge taxonomies. *Electronic Journal of Science Education,* 3(4), 1-18.

Veenman, S. (1984). Perceived problems of beginning teachers. *Review of Educational Research,* 54(2), 143-178.

Wang, J., Odell, S., & Schwill, S. (2008). Effects of teacher induction on beginning teachers' teaching: A critical review of the literature. *Journal of Teacher Education*, 59(2), 132-152.

Wilkins, E., & Clift, R. (2007). Building a support network for new teachers. *Action in Teacher Education, 28*(4), 25-35.

Wlodkowski, R. J. (1999). *Enhancing adult motivation to learn: A comprehensive guide for teaching all adults.* San Francisco: Jossey Bass.

Wojnowski, B., Bellamy, M., & Cooke, S. (2003). A review of literature on the mentoring and induction of beginning teachers with an emphasis on the retention and renewal of science teachers. In J. Rhoton, & P. Bowers (Eds.), *Science Teacher Retention: Mentoring and Renewal. Issues in Science Education* (pp. 22-33). Arlington: NSTA Press.

Appendix

Beginning Teacher Questionnaire

STEMMP – Mentee Post Survey 1

Part 1 of 2

The purpose of this survey to assess how the program has or has not met your needs and how you think it can be improved. You may see duplicate questions from the first and second mentee survey. This information will be used to help improve this year's program and future programs. This should take approximately 10 minutes to complete and will be kept confidential.
THANKS SO MUCH for your help on this!
Joel Donna

Demographics
First Name

____

Last Name

____

Are you gaining graduate credit from the U of M for participating in STEMMP?

Yes - I am in Anne's Face to Face Class (CI 5539 Section 1)
Yes - I am in Joel's Online Class (CI 5539 Section 2 or Independent Study)
No

How long have you been teaching (include this year)?

1
2
3
4+

Do you have a formal mentor outside of STEMMP?

Yes - I have a formal mentor, but they are not in my content area (i.e. I teach science they teach history)
Yes - I have a formal mentor, and they are in my content area BUT they are not in my same domain (i.e. I teach Physics and they teach Biology)
Yes - I have a formal mentor, and they are in my content area

No - Do not have a formal mentor outside of STEMMP

If you have a formal mentor outside of STEMMP, how satisfied are you with them?

Very satisfied
Somewhat satisfied
Neither satisfied nor dissatisfied
Somewhat dissatisfied
Very dissatisfied

Do you have other teachers who teach the same subject or classes that you teach in your building that you receive formal or informal support from?

Yes
No

Did you have any common planning time with other teachers?

Yes
No

Did you participate in any workshops or professional development for new teachers beyond school orientations?

Yes – in the beginning of the year and then some work within the school year
Yes – only in the beginning of the year
No

On average, how many preps did you teach each semester, quarter, or trimester through the year? (i.e. if your day was 2 sections of physical science, 1 section of integrated chemistry, and 1 section of Chemistry 1-1 that would be 3 preps or 3 unique new classes that you prepare for each day)

____

Of these preps, roughly how many of these were out of your licensure area?

____

Did you have to do any traveling between schools?

Yes
No

Are there any other school contexts or unique situations that may have hindered or helped your participation in STEMMP?

____
____
____

How would you characterize your level of involvement with the STEMMP program?
5 – Fully involved in the program and have met all requirements
4 – Mostly involved and have met most of requirements
3 – Somewhat involved and have met some of the requirements
2 – Partially involved and met few of the requirements
1 – Rarely involved and met very few of the requirements

Job Satisfaction/Retention

To what extent do you agree with the following statement? I am generally satisfied with being a teacher.

Strongly Agree
Agree
Neutral
Disagree
Strongly Disagree
Additional comments:

___

If you could go back to your college days and start over again, would you become a teacher or not?

Certainly would become a teacher
Probably would become a teacher
Chances are even for and against
Probably would not become a teacher
Certainly would not become a teacher
Additional comments:

___

How long do you plan to remain in teaching?

As long as I am able
Until I am eligible for retirement
Will probably continue unless something better comes along
Definitely plan to leave teaching as soon as I can
Undecided at this time
Additional comments:

___

Are you planning on returning to your current school next year?

Yes
No

Unknown at this time

If you are not returning to your school next year or are unsure, can you explain why you are or could be leaving your school next year?

____

____

____

If you are not returning to your school next year or are unsure, will you look for another teaching position next year?

____

____

Needs Assessment

Please choose the response for each item that most closely indicates your level of need for assistance in the area described.

	Very high need for assistance in this area	High need for assistance in this area	Moderate need for assistance in this area	Little or no need for assistance in this area
Finding out what is expected of me as a teacher				
Communicating with the Principal/Director				
Communicating with other teachers				
Communicating with parents				
Organizing and managing my classroom				
Maintaining student discipline				
Obtaining instructional resources and materials				

Planning for instruction				
Managing my time and work				
Diagnosing student needs				
Evaluating student progress				
Motivating students				
Assisting students with special needs				
Dealing with individual differences among students				
Understanding the curriculum				
Using a variety of teaching techniques				
Facilitating group discussions				
Using cooperative learning techniques				
Understanding my legal rights and responsibilities as a teacher				
Dealing with stress				
Dealing with union-related issues				
Utilization of				

technology				
Using inquiry teaching strategies or other reform based techniques				

Which of the following is your primary concern at this time?

Finding out what is expected of me as a teacher
Communicating with the Principal/Director
Communicating with other teachers
Communicating with parents
Organizing and managing my classroom
Maintaining student discipline
Obtaining instructional resources and materials
Planning for instruction
Managing my time and work
Diagnosing student needs
Evaluating student progress
Motivating students
Assisting students with special needs
Dealing with individual differences among students
Understanding the curriculum
Using a variety of teaching techniques
Facilitating group discussions
Using cooperative learning techniques
Understanding my legal rights and responsibilities as a teacher
Dealing with stress
Dealing with union-related issues
Utilization of technology
Using inquiry teaching strategies or other reform based techniques
Other (please specify)

If you selected other please specify:

Beliefs

This section is designed to help us gain a better understanding of the kinds of things that create difficulties for teachers in their school activities. Please indicate your opinion about each of the statements below.

	1. Nothing	2. Very Little	3. Some Influence	4. Quite A Bit	5. A Great Deal
How much can you do to control disruptive behavior in the classroom?					
How much can you do to motivate students who show low interest in school work?					
How much can you do to get students to believe they can do well in school How much can you do to get students to believe they can do well in school work?					
How much can you do to help your students value learning?					
To what extent can you craft good questions for your students?					
How much					

can you do to get children to follow classroom rules?					
How much can you do to calm a student who is disruptive or noisy?					
How well can you establish a classroom management system with each group of students?					
How much can you use a variety of assessment strategies?					
To what extent can you provide an alternative explanation or example when students are confused?					
How much can you assist families in helping their children do well in school?					
How well can you					

implement a variety of learning strategies?					

STEMMP

Which of the following have you support through? (Please select all that apply)

[] Mentor/Mentee Chat room Meetings
[] Mentor/Mentee Forum Messages
[] Mentor/Mentee Email
[] Other Mentor Communication (face to face, phone, etc)
[] Small Learning Community (SLC) Chat Room Meetings
[] Small Learning Community (SLC) Forum Messages
[] Larger Public Help Forums
[] Face to Face Meetings at TIES
[] WIKI
[] None of the above

Which of the following choices do you most prefer to receive support from? (Please Choose One)

Mentor/Mentee Chat room Meetings
Mentor/Mentee Forum Messages
Mentor/Mentee Email
Other Mentor Communication (face to face, phone, etc)
SLC Chat Room Meetings
SLC Forum Messages
Larger Public Help Forums
Face to Face Meetings at TIES
WIKI
None of the above

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
The Face to Face Meetings at TIES						
The OLD STEMMP requirements/activities						
The NEW STEMMP Requirements/activities						
The clarity of the directions for activities						

The overall relevance of the activities						
The ease of navigation of the site						
The time required for participation						
The Overall STEMMP Program						

Please explain your satisfaction level in regards to the overall STEMMP program

____
____
____

What about the STEMMP program do you find most valuable?

____
____
____

How would you improve the STEMMP program?

____
____
____

Was there anything that you felt limited your overall participation in STEMMP? What, if anything would have helped you engage more?

____
____
____

Do you think the STEMMP program has made an impact on you personally/professionally? Your students? Your school? If yes, in what ways?

____
____
____

To what extent do you agree with the following?

I believe that STEMMP has had an impact on....

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
me professionally					
my classroom management					
the strategies, activities, and lessons I use					
my work with individual students					
my ability to motivate students					
my reflection on my teaching					
my job satisfaction					
my students' learning					
other teachers in my school					
my beliefs about collaboration with peers					

If you had to do it over again, would you have participated in STEMMP?

()Yes
()Maybe
()No

If you are not tenured, would you consider participating in STEMMP another year?

()Yes
()Maybe
()No

Would you be willing to participate in a short phone interview to discuss STEMMP further?

Yes
No

Do you have any other final comments?

STEMMP – Mentee Post Survey 2

Part 2 of 2

The purpose of this second survey to assess how the specific parts of the program have or have not met your needs and how it can be improved. This information will be used to help improve this year's program and future programs. This should take approximately 10 minutes to complete and will be kept confidential.

THANKS SO MUCH for your help on this!

Joel Donna

Technology

How comfortable are you with the following technologies?

	I have not heard of this	I have heard of this, but am not comfortable	I am comfortable with this technology, but would like to learn more about this	I am very comfortable with this
Instant messaging				
Wikis				
discussion boards/forums				
chat rooms				
Moodle				
web cameras for video chatting				

How would you rate your satisfaction with the technology used in STEMMP

() Very satisfied
() Somewhat satisfied
() Neither satisfied nor dissatisfied

() Somewhat dissatisfied
() Very dissatisfied

What about the technology used to support STEMMP did you find valuable?

____
____
____

How would you improve the technology used to support STEMMP?

____
____
____

Has technology limited or hindered your overall participation in STEMMP? If so explain? How could you improve this?

____
____
____

How would you rate your satisfaction with the email notification used in STEMMP
() Very satisfied
() Somewhat satisfied
() Neither satisfied nor dissatisfied
() Somewhat dissatisfied
() Very dissatisfied

Where did you most frequently participate with the STEMMP program?
() At school before or after the school day
() At school during the school day
() At home or other location

Mentor/Mentee

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
Mentor/Mentee Chat Room Meetings						

Mentor/Mentee Forum Messages						
Mentor/Mentee Emails						
Mentor/Mentee Other Communication (face to face, phone, etc)						
Your Mentor Overall						

Please explain your satisfaction with your mentor

____
____
____

What about your mentor/mentee relationship (in terms of your conversations, the activities you did, resources received, etc) did you find most valuable?

____
____
____

How would you improve mentor/mentee relationship (in terms of your conversations, the activities you did, resources received, etc)?

____
____
____

If you didn’t participate much in the mentor/mentee conversations, can you explain why? What, if anything would have helped you engage more?

____
____
____

Which of the following do you prefer as your method of communication with your mentor? (Please choose one)

() Mentor/Mentee Chat Room Meetings
() Mentor/Mentee Forum Messages

() Mentor/Mentee Other – Emails
() Mentor/Mentee Other – Face to Face
() Mentor/Mentee Other – Phone
() None of the above

If you preferred mentor/mentee emails, face to face, or phonel as your method of communication can you explain why?

____
____
____

Small Learning Communities (SLC)

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
SLC Chat Room Meetings						
SLC Forum Messages						
SLC Dilemma Discussions						
Your SLC Members						
Your SLC Facilitator						
The level of community developed in your SLC						
Your SLC overall						

Please explain your satisfaction level in regards to your SLC

____
____
____

What conversations, resources, or work with your SLC did you find most valuable?

____
____
____

How would you improve your SLC or the work your SLC did?

____
____
____

If you didn’t participate much in the SLC dilemmas, can you explain why? What, if anything would have helped you engage more?

____
____
____

Did you ask for help obtaining resources or solving a problem within your SLC? Why or why not?

____
____
____

Which of the following choices do you most prefer to communicate with your SLC? (Choose One)

() SLC Chat Room Meetings
() SLC Forum Messages
() Face to Face Meetings at TIES
() None of the above

Inquiry 2

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
Inquiry 2 Activities						
Inquiry 2 Group						

Members						
Inquiry 2 Facilitator						

What conversations, resources, or work with your Inquiry 2 did you find most valuable?

____
____
____

How would you improve Inquiry 2?

____
____
____

If you didn’t participate much in the inquiries, can you explain why? What, if anything would have helped you engage more?

____
____
____

Blogs

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
Blogs						

What about the blogs did you find most valuable?

____
____
____

How would you improve the blogs?

____
____
____

If you didn’t participate much in the blogs, can you explain why? What, if anything would have helped you engage more?

____
____
____

Wiki

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
Wiki						

What about the wiki did you find most valuable?

____
____
____

How would you improve the wiki?

____
____
____

If you didn’t use or contribute much to the WIKI, can you explain why? What, if anything would have helped you engage more?

____
____
____

Public Large Group Help and Idea Forums

How would rate your satisfaction with the following?

	Very satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Very dissatisfied	I haven't used
Public Large Group Help and Idea Forums						

If you didn't participate much in the Public Large Group Help and Idea Forums, can you explain why? What, if anything would have helped you engage more?

____
____
____

Any additional comments about the overall program?

____
____
____