EXAMINING INSERVICE TEACHERS' MENTAL MODELS ON TEACHING SCIENCE THROUGH ONLINE LEARNING

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ABSTRACT
Teachers' practice is influenced by their own experiences, their existing beliefs –or mental models –of what teaching and learning is. These mental models have been believed to be very persistent and arduous to change. This qualitative case study describes the shift that took place in the practice of teachers after a two-year online fellowship focusing on online resources. Data collected from phone interviews and teachers' writings and coursework illustrated existing mental models at the start of the fellowship, rooted in early education experiences. By the end of the program, participants largely had changed their instructional methods, moving toward more inquiry-based practices and a marked increase in the use of technology in the classroom.
Keywords: science and math education; teacher education; professional development

INTRODUCTION
Changing teachers' practice to incorporate new methods or technology can be a daunting task. Often efforts to do so may be unsuccessful or met with resistance, in part due to an individual's strong sense of how teaching should be done, based on personal experience. Although resistant to change, existing mental models for teaching are not impermeable. This study examines how teachers taking part in an online professional development fellowship alter their practice and ultimately adjust their mental models for teaching to include new methods and technology.

THEORETICAL FRAMEWORK
Mental Models
The term 'mental model' was coined by psychologist Kenneth Craik in 1943 to describe how a person creates expectations of a given situation in one's mind. Mental models are built through experience and can be extraordinarily complex. They influence the way an individual solves a problem and behavior (Gentner and Stevens, 1983; Johnson-Laird, 2001). Teachers' methods of instruction and how teachers interact with learners are both rooted in the mental models teachers possess, which research has shown are more influential than their content knowledge (Strauss, 2001). Clandinin and Connelly's (1985, 1986) research into teacher narratives illustrate how the teacher cannot be thought as separate from his or her own knowledge – that his or her ways of teaching are as deeply personal as one's own life story. That view lends itself to why these mental models are persistent, because they are rooted in one's individual experience. Pajares (1992) explains how difficult it can be to alter existing mental models. Teachers are considered 'insiders' in their field, because they are not strangers to the classroom. Unlike a surgeon, for example, teachers have grown up going to school in nearly every case, whereas a surgeon may not ever enter an operating room until adulthood. 'For insiders, changing conceptions is taxing and potentially threatening. . . . [they] have commitments to prior beliefs, and efforts to accommodate new information and adjust existing beliefs can be nearly impossible' (p. 323). Lortie (1975) makes a similar argument and explains how 'those planning to teach form definite ideas about the nature of that role' (p. 65) through experience starting at a young age and socialization. Others have found that mental models or existing beliefs about teaching can be very resistant to change (Block & Hazelip, 1995; Patrick & Pintrich, 2001; Richardson, 1996; Woolfolk Hoy & Murphy, 2001). But there is a body of literature that details interventions aimed at altering teachers' beliefs or mental models. Some preservice science methods courses have utilized various mean such as: reflection (Bryan & Abell, 1999), dialogue (Harrington & Hathaway, 1995), and through a book club, which combines both critical dialogue and reflection, (Moore, 2008b). Further, the expansion of existing mental models has been documented through research on preservice programs (Anderson 2001; Author, 2010; Hollingsworth, 1989; Wilke & Loshe, 2012).

Professional Development and the Fellowship Project

Research shows that effective professional development for educators engages them in tasks relevant to their classroom practice, such as examining student work or developing unit plans or rubrics. Teachers must be given the chance to perform their own investigations, and also to engage in professional discussions about their learning with other educators (Avalos, 2011; Ball & Cohen, 1999; Lumpe, 2007). Providing teachers with occasions to build strong understandings of science content and process, as well the opportunity to practice with these new ideas assists teachers in bringing inquiry-based practices into their classrooms (Jeanpierre, Oberhauser, & Freeman, 2005). Instructors must hold high expectations for participants, requiring them to demonstrate proficiency with new ideas. A large scale study (Supovitz and Turner, 2000) showed that science teachers engaged in intense professional development used inquiry-based practices and implemented a more investigative classroom culture significantly more frequently than those who did not participate in such experiences. A review of 360 studies over 25 years found that hose teachers that are given the opportunity to learn through a long-term (more than one year), constructivist approach to professional development in which teachers learn by doing and using inquiry-based practices themselves have been shown to be significantly more likely to incorporate inquiry and technology-based teaching practices in their own classrooms (Gerard, Varma, Corliss, & Linn, 2011).

The educators in this study were inservice teachers who were a part of a program we refer to as simply the fellowship here, a national competitive fellowship program *(name and additional details revealed following peer review of this article*). Fellows complete a series of five online graduate courses aimed at improving classroom instruction in the science, technology, engineering and mathematics (STEM) disciplines. The fellowship program and this study were built upon the framework of social constructivism, in which learners share their own world experiences and intertwine them with those of others, in this case, other fellows. This approach is valuable for students, as well as teachers (Eun, 2008). Knowledge is therefore collaboratively constructed through interaction and knowledge-building between teachers (Richardson, 1997). This framework means that, 'there are social aspects of the construction process; although individuals have to construct their own meaning...the process of constructing meaning always is embedded in a particular social setting of which the individual is a part' (Duit & Treagust, 1998, p. 8). Fellows were always encouraged to share their ideas and experiences, which were used for starting points for learning (van Driel, Beijaard, & Verloop, 2001). Teacher co-learning has been shown to be an important aspect of quality professional development, whether online or in person (Archambault, Wetzel, Foulger, & Williams, 2010; Avalos, 2011; Timperley, Wilson et al., 2007).

The fellowship program was designed to provide a high quality, intensive professional development experienced based on research in the field. Throughout their coursework, fellows were given multiple opportunities to build and reflect upon their content knowledge and STEM pedagogical strategies, such as inquiry-based science lessons, engineering design, and incorporating technologies (e.g., visualizations, podcasts, data analysis tools) to improve understanding of concepts. Each instructor stressed the importance of these and other practices, and gave fellows opportunities to try out ideas, and then reflect on them with both instructors and other fellows. The five-course series provided frequent opportunity for learning, reflection, discussion with outside experts, i.e., instructors and professionals in the STEM fields, and had clearly stated goals, all hallmarks of excellence in science teacher professional development (Timperley, Wilson et al., 2007).

Online Learning for Teachers

Studies indicate that online professional development is at least as effective as in-person training, and also less expensive and more efficient (Barker and Brooks, 2005, Schmeekle, 2003). Distance learning courses can, however, result in feelings of isolation, and therefore interactions between students, as well as between students and instructors were critical design components of online courses to mitigate this feeling of disconnectedness (Northrup, 2000; Threlkeld & Brzoska, 1994). The fellowship program is very unique in that it brings teachers and instructors from across the country together through the use of a blended model of synchronous and asynchronous technology, which has been shown to be effective in both engaging educators and allowing for meaningful discourse between participants and between participants and instructors. Teachers tend to appreciate the flexibility of this model (Author, 2010). Carr-Chellman (2000) also notes the importance of synchronous interactions, which,

> . . . include a more direct sense of collegial interaction, immediate resolution to questions posed, and possibly a strong contribution to the team building required to sustain future student interactions. The synchronous mode is particularly appropriate for the inclusion of motivating guest lectures in specific content areas. (p. 236)

Guest lecturers in the fellowship courses included practicing scientists, mathematicians and engineers. These experts were included in order to give fellows practical applications to the STEM fields. Design of the courses reflects the research in online training, although most studies refer to asynchronous interactions, e.g., using message boards and recorded lectures. Research also notes that online courses can be very relevant to teachers' classroom experiences (Mackey, 2009), and that teachers view online professional development as meaningful (Duncan-Howell, 2010). Like in other forms of teacher professional development, online instructors should take the role of a facilitator, assisting the teachers through their own learning processes (Palloff & Pratt, 2011).

RESEARCH QUESTION

The purpose of this study was to examine the role of mental models during a reflective, teacher-chosen professional development. Participants applied to the competitive fellowship and, as part of their coursework in the fellowship, shared reflective writings on both their own learning experiences as children and on their teaching practice. These data, combined with other artifacts, allowed researchers to understand the participants' mental models at the start of the fellowship and provided opportunities to revisit what these models looked like for their instructional practice during, and at the end of the fellowship. We sought to discover: In what ways are teachers' mental models of teaching influenced by participation in an intensive online fellowship program?

METHODOLOGY

To learn more about reported changes in teachers' practice during the fellowship and how they might relate to teachers' mental models on teaching science, this qualitative case study was constructed to examine the experiences of 14 inservice teachers who had completed a STEM teaching certificate program as part of a fellowship. Through analyzing coursework of the participants, exit interviews and surveys, the case is drawn for the group as a whole, while highlighting individual participants to provide details about their experiences. The study was conducted over two years, during their fellowship. The researchers had contact with all of the participants through coursework, phone conversations and email.

Case Study

The approach of interpretive case study education was selected to share findings with the community of teacher-educators (Guba & Lincoln, 1981). This method of analysis and sharing findings allow the researchers to utilize 'description, interpretation' and 'identif[ication] of recurrent patterns in the form of themes' (Merriam, 1998, p. 12) to richly describe the case. The case was bounded as the members of the first cohort of the fellowship program who responded to the survey and was drawn specifically around three members who also participated in phone interviews. The data collected was chosen to illuminate the experiences, attitudes and practices of participants in their own words.

Setting & Participants

This study was conducted during a two-year fellowship program called simply the fellowship in this paper. In this 5-year funded initiative, fellows were competitively selected to participate in the two-year online program. The ultimate goal of the project was for educators to become highly-qualified science teachers, as designated by the US government (For a teacher to be 'highly-qualified,' he or she must hold a bachelor's degree in the given subject area; hold full licensure by the state in which he or she teaches; and demonstrate core competence in the subject area taught (US Department of Education, 2004)), in their state and to enact change in their classroom, school, and school district in order to inspire and prepare more students for STEM careers. This study examined the experiences of 14 of these fellows. The American male and female fellows in this study taught in various states across the country and included elementary generalists, special educators, gifted educators, teachers of all science disciplines, technology and math teachers. Fellows also ranged in years of experience, from first-year teachers to those nearing retirement and represented diverse ethnicities. The fellows took five graduate courses while teaching full-time and earned a Certificate in STEM Education. The five courses included two required pedagogically-based courses and three STEM elective courses. All courses were held online using a blended synchronous and asynchronous model that included 4-6 live sessions as well as structured discussions and other assignments. The online learning system included many common features seen in asynchronous online learning environments including discussion boards, blogs, quizzing and grading capabilities. It was served as the center of all interactions between fellows and instructors as well as between fellows. Discussion boards within the online learning system had a feel that is a hybrid of traditional asynchronous systems (i.e., Blackboard WebCT) but with a social networking flavor. Each discussion post is accompanied by a photograph or avatar of the fellow and viewing each person's profile requires just one click.

Data Collection & Analysis

All of the data for this study was collected remotely – either by phone or via the Internet, through an online learning system, an online survey generator and email. There were three main sources of data: semi-structured exit interviews via phone, an electronic survey and teacher coursework. The coursework examined included course discussion posts and particular assignments, such as a science autobiography that participants wrote at the start of their fellowship and an action research project they completed at the end of the program. In addition, the researchers' own experience as instructors for the fellowship allowed us to reflect and observe the participants during the two years, while we interacted with them through the fellowship. This relationship can be viewed as one of a 'researcher teacher' doing 'self-study research' in that the researchers were studying the program as a whole, in which they were each teaching several of the courses that comprised the program (Roth, 2007, p. 1210). This type of relationship is desirable, as it 'brings teachers' voices into the larger science education research community' (p. 1219) as well as increases the rigor of the study, due to the 'long-term observation' (Merriam, 1998, p. 204) of participants and the intimate knowledge of the program studied by the researchers, giving them 'insider status' (Roth, 2007, p.1210).

To analyze the data, electronic files of participant coursework were sorted into folders for each participant and coded openly for broad categories and themes, utilizing Atlas TI. Similarly, interview transcripts were made from digital recordings and also sorted and openly coded. It was not until this first pass of coding was completed that the theme of mental models clearly emerged. Once that theme was recognized, the entire set of data was again coded; using the lens of mental models, and additional questions arose. At this juncture, a survey was created through Survey Monkey and was distributed to participants. This survey consisted of several open-ended questions allowing a free response. The responses were sorted and coded and then compared both among participants and within a participants' own set of responses. During the analysis, the researchers' own experiences with each participant and within the organization helped to construct and organize findings.

FINDINGS

The data sources revealed that teachers reported, in many cases, drastic changes in their practice after participating in the online fellowship. Particularly, teachers said they used a more inquiry-based approach to science teaching and utilized more technology or technology in a more advanced or meaningful way. It was also noted that many teachers' experiences in science as a child were later played out in some form in their teaching practice, which was then altered in some way after the fellowship. These findings point to a change or shift in participants' mental models of science teaching.

The data from the questionnaires revealed that the majority of participants did not have access to technology or inquiry-based activities during science class as students in grade school, nor did their own science lessons utilize technology or inquiry practices. Although 'hands-on' activities were mentioned by half of respondents, only one teacher reported an inquiry experience as part of grade school science work. The technology experienced by participants as young learners was limited: six reported having viewed film strips and VHS, two experienced overhead projectors and transparencies and one reported the use of a telescope.

These experiences largely laid the groundwork for future practice: Hands-on work was cited as utilized by six of the seven that experienced hands-on work themselves. Of the 14 participants, five mentioned presenting inquiry lessons at some point during the school year to students during their teaching at the start of the fellowship. The frequency of these lessons during the school year was for only one or two topics of study for two teachers, often for another teacher 'because of focused professional development,' and not specified for two teachers. However, none of these inquiry activities were cited to utilize technology. Some examples of participants' reporting of their STEM teaching practice before participation in the fellowship:

> *Dan:* 'My typical lesson was hands-on but they were isolated one-offs.'
>
> *Patty:* 'I tried to orient my lessons around hands on activities, but they were more like following a recipe where everyone was supposed to have the same outcome.'
>
> *Joe:* 'Read and discuss text and answer questions'
>
> *Anna:* 'We took notes, built models, and read out of the book'
>
> *Lori:* 'A typical lesson was more script based, by the book, with a pre determined outcome. I would present instruction in a step by step manner without deviation'

In contrast, the technology use of the teachers was vastly different from their own experiences, likely because of the availability of computers and internet access in recent years. The technology the majority (ten) of participants mentioned using with their students largely included computers or SmartBoard technology (three). Other forms of technology mentioned individually, each by different teachers, were: document camera; digital probes; and overhead projector. However, the types of activities conducted using the computer was limited to viewing videos, PowerPoint presentations, webquests and student research. For example, some teachers responded:

> *Kim:* 'The typical lessons that were provided by the district had some websites and overheads that were

> reproductions from the workbook.'
> *Lori:* 'My science lessons would include students making a picture on the computer using stamper tools and typing vocabulary words from the lesson.'
> *Patty:* 'The only technology I would use with science was a Smartboard. It was a good way to gather data and have students participating in showing their results.'
> *Joe:* 'Computer labs for research and smart board lesson made by me to teach. Notes with short video clips from sites like Teachersdomain.org.'
> *Charlie:* 'Use of YouTube as 'engage' for students, PowerPoint review presentations, Document Camera to show student work, on a daily basis.'

After their completion of the fellowship, the majority of participants reported dramatic changes in their practice. All participants reported an increase in the frequency of or the inclusion of inquiry lessons (except for one teacher who had recently changed jobs and was solely doing test preparation), with two teachers reporting they now use inquiry 'daily' and with every science lesson compared to none before the fellowship.

> *Nancy*: 'My typical lessons are very detailed in inquiry base learning and hands-on manipulatives with use of graphic organizers and SMART BOARD materials.'
> *Patty:* 'A typical science lesson now is much more inquiry oriented. I give students a chance to explore the concept in some way to generate their own ideas and uncover misconceptions first, then I help them acquire some content in the concept before having them explore their own questions within the parameters I set.'
> *Kim:* '[Three] days a week is the typical for inquiry lessons, however they usually build on each other throughout the week.'

The majority of participants also cited increased use of technology in varied, seemingly more meaningful ways, including the use of specific instructional tools they learned through the fellowship.

> *Dan:* 'I infuse lots of technology now. My students write reflective blog entries about their week. They research online. They will soon be creating videos in class. They document their lab experiences digitally. They have online discussions about what goes on in class.'
> *Patty:* 'I no longer have a smartboard, so I don't use that for my lessons. I do incorporate 3D view lessons and plan to use the data from Signals of Spring in a long term project this spring.'
> *Anna:* 'I use several NASA programs such as AstroVenture'
> *Lori:* '[An] example lesson is a rocketry unit I do with 5th grade. Students are put in teams. . . . Students also explore flight and rocket structure through creation and testing of straw rockets. Student then use laptop computers to research design ideas for creating a water bottle rockets. They agree upon a design, create the rocket, then we have a launch day to test them and discuss results.'

A theme of increased use of inquiry and technology in the participants' classroom was evident through their responses to the open-ended questionnaire. Although inquiry lessons and technology were not foundations of their own education in science in grade school, the teachers' experiences through the fellowship played a role in changing their teaching practices. These changes, as they relate to the program were also evident in the other data sources.

Lori. Lori has a passion for hands-on science and utilized animals as a vehicle to getting students immersed in the subject. She provided experiences for her second graders of caring for animals in the classroom, lessons relating to the animals she keeps on her farm, marine science materials made available from Sea World (which is not far from her school) and agricultural lessons related to 'growing crops.' Despite this rich context, in her survey she explained: 'I didn't do any inquiry based lessons due to lack of understanding how to guide them as well as fear of the unknown, so to speak.' She has since become the computer teacher for her school and at the start of this program one of her goals was to bring in more math and science to her lessons. Lori explained in her science autobiography:

> Formal science education as a child was rather sketchy, but growing up on a farm created its own living, breathing scientific community and my main instructor as I learned first hand how animals survived, gave birth and raised their young, how crops grew and what it took to manage those crops. . . . Once I started my career as a second grade teacher, … I incorporated my farming background as kids cared for various animals in the classroom … I occasionally brought my own animals to share when opportunity allowed. I also taught my second graders about growing crops, and eating them as they learned to make strawberry jam.

It is clear the Lori drew upon her mental model of learning science through agriculture experiences as the best way to teach science to her young students. Her own experience and resulting mental model provided a powerful influence on her instruction.

Lori, who was enthusiastic about agriculture in the classroom, found the fellowship was helpful in giving her tools to have students develop knowledge on their own. Similar to her account of bringing animals into the classroom, she 'brought' polar bears and reindeer to her students through an online research project she learned about through [the fellowship]. This extended project, including an online symposium in which students were able to share findings with students in other states, Lori showed that her original mental model of using nature and animals to promote science learning was adapted to use online resources. This change made her feel that students were getting more out of the experience, allowing them to be investigators:

> I am learning how to set up my projects and situations to where they are developing more ownership of what they're doing and learning to be investigators themselves instead of me feeding it to them.

The dramatic shift from being hands-on in the classroom or on the farm, to being online to learn about animals clearly represents a change in how Lori believes science can be taught and learned. Her statements about students doing their own investigations demonstrate that she believes science can and should be learned this way: using tools gained from her fellowship experience. This is a big mental model adjustment, but although it is a change, her fundamental ideals about teaching science remain intact, channeled through this new resource.

Anna. In her science autobiography, Anna talks about her deep and life-long interest in the 'natural world.' After being dissuaded from a career in wildlife biology by a counselor who did not think it was a good choice for her because of her gender, Anna worked briefly as a social worker and then became a teacher. She has now been teaching for six years, and teaches all of the fourth grade science in her school. Even though she is a leader in science instruction there, the majority of her lessons before the study were not inquiry-based and she felt uncomfortable with inquiry activities. Despite her inclusion of hand-on lessons and animals and insects, particularly, in the classroom, she sought more training in science instruction and was pleased to be accepted to the fellowship.

In her science autobiography, Anna vividly recalled her childhood science experiences involving insects, fish and crustaceans. As a fourth-grade teacher, she tries to excite students by using similar creatures in her lessons:

> From the time I could walk, my parents took me to the Platte River and explored. Every year when the Platte would go dry and leave little pools, we would head down there with our dip nets and see what was left behind. We would catch crayfish, minnows, leeches, and sometimes large carp which we would set free into the channel. It was great fun. … My mom, since we had chickens that set on their own eggs would talk to us about what was going on in the egg, help the babies out of the eggs, and sometimes go bug hunting with us just for fun. … My parents got me a microscope set with a dissection kit, specimen jars, and brine shrimp! I thought I was in heaven! Those brine shrimp were the most interesting thing that I had ever seen up to that point in my life, and I had great fun with them. . . . I love to show children things that they have never been exposed to before … In my classroom I have a colony of Madagascar hissing cockroaches. Kids are fascinated by those large insects. The girls that squeal at them at the beginning of the year soon learn that they are nothing to fear. I also bring a Garter snake in every year

Anna's account illustrates how existing mental models formed from experiences learning science provide a model for instruction. Similar to Lori, Anna reported that her teaching practice changed dramatically after her involvement in the Fellowship, but still harked back to her previous experiences. Anna shared in her survey that her science lessons before the fellowship consisted of 'tak[ing] notes, build[ing] models and read[ing] out of the book.' Her capstone project for the program, an action research study, focused on inquiry and hands-on experiences with insects for her students to explore female students' feelings about bugs. She has also increased the frequency of inquiry lessons from once a school year to two to three times per month. Although Anna reports she is 'still uneasy' with inquiry, it is clear that her professional development experience played a large role in changing her practice and her mental model of what science teaching should be.

Patty. Patty has been in the classroom for more than eight years, but this is actually a career change for her. She worked as a physical therapist for 18 years and then went back to school to become an elementary school teacher. In addition to her time in the classroom, she also teaches an after-school science magnet program and has been a science specialist. Even though she is an experienced science teacher, before the study, Patty described hands-on activities she conducted with students as formulaic in nature and with one desired outcome. She did not attempt many inquiry activities in her practice and, according to her survey, felt like she 'didn't really know what [she] was doing.'

Patty cited in her survey that she did not remember any elementary science experiences and explained in her autobiography that her mental model for teaching in general arose from her experience with patients in her former career:

> Both my training and work … showed me what scientific thinking was about. Early on, I learned to evaluate patients

> and rely on the data I collected (both subjective and objective) to formulate working diagnoses and treatment plans. As a young physical therapist, the information I gathered often felt disconnected as I struggled to understand the significance of individual tests. As I became more experienced and adept at evaluation, patterns began to emerge and I saw connections between seemingly incongruous pieces of information when I would evaluate and treat patients. . . . Developing an effective treatment plan was like putting the pieces of a puzzle together. . . . Physical therapy was a constant interplay between evaluation and treatment. For me, they went hand in hand. . . . As my footing as a teacher became firmer, I began to apply what I'd knew about people and learning from my days a physical therapist to my teaching. I really worked at evaluating students and their response to learning on many different levels. What were they good at? What type of learner were they? What skills did they have? How could I help them feel successful? What could I do to help them connect to learning? . . . I was still thinking like a scientist and applying those skills to my new situation as a teacher.

Patty has a strong mental model of utilizing evaluation techniques and familiarity with her students to drive her practice. Through the fellowship, she was able to change that model to incorporate inquiry practices. Patty feels strongly about this new direction in her teaching, so strongly that she is sharing it with her colleagues and administration.

> What I learned both from the methods class and the research I did - in terms of what's considered best practice right now for teaching science - using an inquiry approach, meta-cognition all those kinds of things. So that's what I share with my teaching colleagues and I also shared with Administration… kind of a perspective of what STEM is and how, how integrated science teaching is really important for kids in terms of making sense in science.

While Patty cites assessment as an integral piece of her instruction even after the study, in her interview, she expresses how she feels a dramatic change in her teaching has occurred: 'My teaching is completely different; I feel confident using an inquiry approach now where I didn't before.' This shows that her mental model of how to teach science has shifted, making inquiry an important part, which she now feels comfortable doing.

DISCUSSION

The goal of this study was to examine teachers' mental models as they participated in an intensive fellowship program that focused on the use of inquiry and real data with students. The findings suggest that two-year online-based program played a role in teachers' mental model change. A review of literature illustrates the difficulty in making changes to mental models (Lortie, 1975; Pajares, 1992). Through interviews, coursework and a questionnaire, it was noted that major changes in teaching practices were evident, especially in terms of utilizing inquiry and technology activities with students. These shifts in practice can be related to changes in their mental models of what science teaching looks like. The progress illustrated in this study is particularly interesting as the use of technology in the classroom increases, which is a departure from the way most teachers learned science.

Participants in this study were in grade school before the advent of the widespread use of computing for personal and educational use. These teachers largely did not learn science in school through technology nor inquiry practices. Some of the teachers did have hands-on school experiences that were not inquiry-based. We are proposing these school-based experiences in learning science had created mental models of science teaching that did not include the use of technology nor inquiry, which was evidenced through participants' own descriptions of their teaching practice before the study. Research shows that teacher beliefs about technology and student learning affects how they use technology to support curriculum (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Ertmer & Ottenbreit-Leftwich, 2010; Kim, Kim, Lee, Spector & DeMeester, 2013). The experiences in the present study, although nearly completely online, encouraged and supported the use of both technology and inquiry in the classroom. This was accomplished through coursework, mentoring and peer interaction. Several participants' teaching changed dramatically, moving from no reported inquiry lessons to daily use of such teaching. Also, the use of technology to do inquiry or support inquiry activities also was reported, which can be interpreted as an increased familiarity and affinity for use of both. The data suggests that the fellowship experience was meaningful enough to spur a change in practice, which we are correlating to a shift in teachers' mental models.

It is also interesting to note, that several of the participants did have informal, out-of-school inquiry experiences that may have laid the groundwork or perhaps pre-disposed them to utilizing inquiry in the classroom, once the connection of how to do that was made clear. Although outside the scope of this paper, this is an important point, since connecting to existing schema and ideas about successful learning, even informal, self-directed childhood exploration, can be valuable (McPherson, 2014). Clearly, more research would be needed to explore this idea.

A compelling point that surfaced is for the teachers Lori, Anna and Patty detailed specifically here, strong existing mental models about the way science teaching should be carried out did not disappear, but instead accommodated the new mental model or shift in mental model. This outcome resonates with the literature that states mental models are extraordinarily hard to change. As reported by the teachers themselves, clearly, practices and mental models DID change, however the change remained within the parameters of original mental models of science teaching (animals, insects, and evaluation). This trend in the data is important to note because it shows both how powerful mental models can be, yet also that they are not impervious. This finding is in line with prior research on preservice teachers who integrated new content into and expanded upon their existing mental models through their teacher education programs (Hollingsworth, 1989; Anderson, 2001). The significance of existing models being malleable in terms of expansion is important to note, as this may be a significant entry point for professional development and growth.

The unique features of the fellowship studied here provided an environment that was rich with both pedagogical and social resources, despite being conducted in its entirety online. In addition, coursework often required reflective pieces to be written; where teachers had the opportunity to think about their practice and how new resources and/or techniques could be implemented in their own classrooms. In general, courses offered choice for assignments and those assignments were largely related directly to an individual's own practice or students. The fellowship provided a forum for teachers to discuss these ideas and projects with other teachers in the fellowship. Professional development literature (Ball and Cohen, 1999; Borko, 2004; Hewson, 2007) cites these as desirable qualities and our findings suggest this highly personal fellowship was very effective in providing an environment where teachers could learn and grow. Teacher growth has been related to shifts in beliefs and mental models in other studies (Bryan & Abell, 1999; Bryan & Atwater, 2002; Moore, 2008). The findings here indicate that there may be a connection between teacher growth and learning and mental model shifts. This blended online format has already been found to promote the growth of professional communities of teachers who share best practices as well to help teachers of science strengthen their conceptions of the Nature of Science and identify and clarify student misconceptions (Author, 2010),

CONCLUSION

All teachers enter the classroom with preexisting beliefs and mental models built from their own experiences that can influence their methods of instruction and expectations of learners (Calderhead & Robson, 1991; Moore, 2008b; Nespor 1987). These existing mental models can be very difficult to change (Lortie, 1975; Pajares, 1992), but some recent studies have found a belief shift may be possible (Bryan & Abell, 1999; Bryan & Atwater, 2002; Harrington & Hathaway, 1995; Moore, 2008). The findings of this study provide support to that idea.

After a two-year, interactive, online fellowship program, teachers provided evidence of teaching practices that had shifted, and in some cases significantly, in terms of inquiry approach and the use of technology. The teachers who participated in this study were not educated in a time when computers were used to aid instruction in grade school and largely did not utilize computers or the Internet in their own teaching. Finding ways to help teachers become more comfortable using digital resources is a challenge. 'The single biggest problem facing education today is that our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language' (Prensky, 2001, p,2). This study provides an example of a model that was successful in providing experiences that that fostered teachers' integration of digital resources into their instructional practice. Generally, this study raises questions on how to help teachers adjust their mental models, which is also important for examining how teachers may learn to incorporate more digital resources in the classroom. We see that providing a learning environment that connects to the new methods, coupled with reflection, can help foster change.

Existing mental models about the way science should be taught were evidenced through teachers' science autobiographies and questionnaire responses. However, due to the nature of the fellowship, where online resources were explained and showcased, participants were able to incorporate these new ideas and actually change their practice. This is a compelling outcome that adds to the growing body of literature that shows changes can be made in teachers' preexisting beliefs, in particular in regard to inquiry-based instruction and the use of technology. These findings suggest that additional research is warranted to uncover what exactly helps facilitate these types of shifts and how preservice education and inservice professional development can better utilize those methods to help support teachers' growth as practitioners in the digital age.

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