Beginning Secondary Science Teachers: Strengthening, Sustaining, or Sinking

Julie A. Luft

Abstract
Supporting beginning secondary science teachers is important if they are going to build their beliefs and pedagogical content knowledge. One way to support beginning science teachers is through science-specific induction programs. In this chapter, a point is made about the need to support beginning science teachers. Then data are shared about the impact of a science-specific induction program on the beliefs and PCK of beginning teachers. From this data, it can be concluded that science-specific induction programs can help beginning teachers strengthen and sustain their beliefs and pedagogical content knowledge. Such programs keep them from swimming, instead of sinking in their first years of teaching.

Keywords
Beginning Teachers, Science Teachers, Teacher Development

INTRODUCTION

Those in science teacher education tend to focus on one of two areas when it comes to teacher development. One area pertains to the preparation of new teachers. In this area, there are discussions that range from the courses that support new teacher learning to how new teachers develop. This research is ultimately conducted to guide the conceptualization and enactment of preservice programs. The other area of research pertains to the professional development of teachers, which often focuses on teachers who are in the classroom full time. Research in this area is often situated within courses, institutes or programs that are developed to specifically enhance a science teacher's ability or skills to teach or work with colleagues.

What is missing in this two-phase approach is attention to the most difficult and challenging time in a teacher's career – the first years of teaching. Preservice science teacher educators often consider this to be a period of time that is not their responsibility. After all, most would reason that they have prepared good teachers and their preparation will enable them to survive the first years – just as everyone does. With this faulty assumption, science teacher educators are actually missing an important opportunity to evaluate the quality of their teacher education program, and to support their teachers in ways that will allow them to strengthen and sustain their abilities, knowledge, and skills.

Science teacher educators who are focused on the professional development of part of a teacher's career often assume that the first years of teaching are difficult and they should be supported by the school in which the teacher works. Unfortunately, this position suggests that new teachers developed ways of teaching that are inconsistent with their preservice teacher education program. In this area, professional development specialists then have the task of providing programs that will bring the experienced teachers back to the abilities, knowledge and skills they developed during a preservice program.

By working with new teachers after they graduate and before they participate in science teacher professional development programs, science teachers can experience a seamless transition from their preservice program to their first experiences with professional development programs. If science teacher educators have the goal of strengthening the abilities, knowledge and skills of science teachers, then they must actively work with science teachers when then need their science education training the most – during their first years. After all, this is a significant and memorable time in the careers of every science teacher.

Over the years, my colleagues and I have worked with and studied early career science teachers. Our goal in this chapter is not to reiterate this work, but our goal is to suggest why science teacher educators should be involved with induction teachers. Throughout the rest of this chapter, I will describe our experiences pertaining to new science teachers. The different areas that are described pertain to supporting new science teachers in order to strengthen and sustain their beliefs about teaching, and their pedagogical content knowledge.

Working With New Science Teachers
Eight years ago, in a study funded by the National Science Foundation, we found and began following over 130 beginning secondary science teachers. For the next five years, we observed and interviewed the teachers to capture the change in their beliefs and pedagogical content knowledge. These teachers were also involved in different induction programs, which gave us new insights into how science specific induction support can impact the long term learning of a science teacher. From this comprehensive data set, we have written several research articles that describe our research process, and new teacher change and development (e.g., Bang & Luft, 2013; Luft, 2009; Luft et al., 2011; Ortega, Luft, & Wong, 2013). The next sections in this chapter are summaries and perspectives on our work with new science teachers in the areas of teacher beliefs and pedagogical content knowledge.

Beliefs of beginning science teachers
Teacher beliefs have long been associated with teacher decisions. Beliefs, or "psychologically held understandings, premises or propositions about the world that are felt to be true" (Richardson, 1996, p. 103). These teacher beliefs often are a result of many years of personal experiences, including those as a student (Richardson, 1996). For example, personal experiences in a teacher-centered classroom may lead a teacher to believe in utilizing teacher-centered practices. Teachers that experienced verification science laboratory activities may believe verification laboratories are the only or best way to teach science. If preservice teachers experienced science in this manner, this influences what they think science is, and how science should be taught.
While teacher beliefs impact teacher decisions, beginning teachers beliefs are often unstable. Simmons et al. (1999) found some teacher beliefs to be more stable depending upon years of experience. Luft (2001) supported this finding when she found new teachers had more pliable beliefs than their more experienced colleagues. While beliefs are unstable during the beginning of a teacher's career, they become more difficult to modify over time. This can be attributed to a system where core beliefs are more central and difficult to change, while peripheral beliefs are more prone to influence (Rokeach, 1968) As a result, beginning teacher beliefs are malleable, but over time they become more stable as they form core beliefs about teaching science.

In our study of beginning secondary science teachers in different induction programs, it was found through quantitative and qualitative research, that beliefs can be influenced by different induction programs. In this study, we conducted a comparative analysis of the teachers in science-specific induction programs to the teachers in induction programs put on by their schools (no or little focus on science). The two science-specific induction programs of interest were an online program and a face to face program. The online program consisted of a web-site in which new teachers and their mentors could discussion teaching inquiry. The face to face program consisted of monthly meetings and monthly classroom visits, as well as online support and a trip to a local science teacher conference. A description of these programs can be found in Luft (2009).

In Luft et al. (2011), it was reported that the teachers in the science-specific induction program developed more student-centered beliefs during the first two years of participation in the induction program. After the induction program ended, the teachers' beliefs returned to their original position. In other words, even though these teachers' beliefs changed toward a more student-centered orientation during their induction program; two years later, they veered back toward the original beliefs that the teachers held when they first started teaching. For the teachers in the other induction groups, where induction was not science-focused, beliefs changed little. The finding that all of the participants' beliefs fluctuated, but did not permanently shift supports the notion that teacher beliefs are malleable as reported by Simmons et al. (1999) and Luft (2001). In addition, this also supports the idea that some beliefs are difficult to change and change may be difficult to sustain (Rokeach, 1968).

Beliefs have a very definite role in teacher decisions. Although it has been shown that it is difficult to change beliefs, it is also very necessary to do so in order for student learning to occur. Teacher beliefs are related to teacher decisions, and it is important that teachers believe in the importance of student-centered instruction. New teacher beliefs are important to change, but more research is needed about how to support the development of these beliefs. Ultimately, if we don't understand how to support new teachers' beliefs towards more student-centered orientations, we will spend more time with in-service teachers trying to modify stable beliefs. These stable beliefs may be inconsistent with the views we value in science teacher education.

The pedagogical content knowledge of beginning science teachers

Good science teachers do many things to promote student learning in the classroom such as lead discussions, plan experiments, and design units. The teaching strategies should involve both subject-specific approaches and science-specific pedagogical strategies (i.e. inquiry). This includes having a repertoire of a wide range of approaches to teaching and learning and the ability to judge when a particular approach is appropriate for a particular situation and when it is not. Most often, it is the experienced teacher that is cognizant of the complexities of various teaching strategies that cause confusion in the learning of science concepts (Clermont, Borko, & Krajcik, 1994). Beginning science teachers, unlike their experiences counterparts, tend to rely on trial and error to help them survive the first years in the classroom.

A science teacher's ability to develop and enact instruction to a particular group of students is based on a teacher's knowledge, which is referred to as pedagogical content knowledge (PCK). This unique knowledge draws upon content knowledge and general pedagogical knowledge, and results in instruction that represents the content area to students (Shulman, 1986, 1987). van Driel, Beijarrd, and Verloop (2001) expanded on the composition of PCK in science by stating that this knowledge consists of 1) an understanding of student difficulties and/or misconceptions with topics related to the content that is taught and 2) instructional strategies that incorporate representations. Furthermore, they indicated that PCK is developed while teachers work in classrooms.

In our study of beginning science teachers, we looked at the development of PCK of 69 teachers over the course of their first three years in the classroom. A PCK interview was used to elicit how teachers' transformed knowledge about content and students into lessons for students (see Lee, Brown, Luft, & Roehrig, 2007). The semi-structured interview occurred prior to the start of the study and after the end of each of the three subsequent years in the classroom. The areas of "Knowledge of Student Learning in Science" and "Knowledge of Instructional Strategies" were captured as the teacher discussed what they considered to be their best lesson. Two researchers coded the responses independently as limited, basic, or proficient and then collectively to resolve any areas of discrepancy. A discussion of the development of this interview and the coding process, as well as the reliability and validity, can be found in Lee et al. (2007).

Table 1. Mean scores and standard deviations for PCK (N=69)

Time	Mean	SD
Before starting teaching		
PCK	1.44	0.36
Category 1	1.39	0.35
Category 2	1.52	0.48
After a year of teaching		
PCK	1.84	0.42
Category 1	1.72	0.46
Category 2	2.03	0.50
After two years of		
teaching	1.55	0.39
PCK	1.48	0.41
Category 1	1.65	0.45
Category 2		
After 3 years of teaching		
PCK	1.75	0.34
Category 1	1.67	0.41
Category 2	1.86	0.40

The overall PCK that the teachers held in this study tended to reside in the beginning categories: basic and limited ($F(2.86, 214.46) = .31$, $p = .811$, partial $\eta^2 = .004$) (see Table 1). As beginners, these new teachers relied on few instructional approaches, did not recognize students' prior knowledge, made few accommodations for diverse learners, used few representations to present the subject matter, struggled to consider the use of inquiry in the lesson and did not change significantly over the year.

In a follow-up analysis, the overall PCK score was broken down into two categories: 1) Knowledge of Student Learning in Science and 2) Knowledge of Instructional Strategies. Category 1, Knowledge of Student Learning, includes students' prior knowledge, variations to students' approaches to learning, and students' difficulties with specific science concepts. Knowledge of Instructional Strategies, Category 2, includes the teacher adopting scientific inquiry practices for teaching a lesson and the use of representations that are pedagogically effective.

There were no significant differences found in the development of PCK in either Category 1 or Category 2 (see Table 1). However, teachers' scores in Category 2 showed the greater growth over the three years. Specifically, teachers moved from a limited to a basic level of PCK, which is characterized as adopting more inquiry-based instruction and adopting more representations to present the subject matter. This finding supports the conclusions of other researchers regarding the importance of working with students in order to improve one's PCK (Lee et al., 2007; Loughran, Muhall, & Berry, 2008; van Driel, de Jong, & Verloop, 2002).

From this and other studies about beginning teachers' PCK, it is clear that working in the classroom is important, and it is important to provide additional support to the beginning teachers in the area of instructional strategies. Clearly these areas, which are developed during a preservice program, need ongoing support in order to achieve high levels of proficiency. These collective findings add to a growing amount of data that suggest learning to teach does not just happen during one's preservice program, but that learning to teach takes place over a period of time.

CONCLUSION

In our work with beginning science teachers, we know that they come to the profession with different abilities and different instructional needs. These differences are captured in the previously mentioned sections, and they support the need to consider how preservice teachers are prepared when it comes to their teaching beliefs and PCK. Clearly, the only way recommendations for preservice education can be made are when we study new teachers. By looking at the performances and knowledge bases of new teachers, we are able to better understand how preservice and induction programs support teachers.

In this chapter, it is clear that new teachers have a different pattern of development over time. Science teacher educators need to extend beyond their view of preservice and inservice teachers, and adopt a view of teachers that recognizes the important area of induction. By viewing teachers as progressing from preservice, to induction, and to early inservice, programs that prepare and support teachers can be developed and enacted by teacher educators. These programs ensure that early career teachers are supported in ways that allow them to perform beyond the training of their education program and in a way that is appropriate for their phase in their career. By recognizing the important role of induction in a teacher's career, we can build new and powerful ways to strengthen and sustain the beliefs and PCK of teachers.

AUTHORS' NOTE

The authors of this chapter would like to recognize the following research assistants and faculty who helped with various parts of this study: Charles Weeks, Gillian Roehrig, Anne Kern, Sissy Wong, Krista Adams, Ira Ortega, Jennifer Neakrase, and Holly Crawford. This study was made possible by National Science Foundation grants 0550847, 0918697, 0732600, and 0632368. The findings, conclusions, and opinions herein represent the views of the authors and do not necessarily represent the view of personnel affiliated with the National Science Foundation.

Julie A. Luft *(jaluft@uga.edu) is the Athletic Association Professor of Science and Mathematics Education, in the College of Education, at the University of Georgia, Athens.*

REFERENCES

Bang, EunJin, & Luft, Julie A. (2013). “Secondary science teachers’ use of technology in the classroom during their first 5 years.” Journal of Digital Learning in Teacher Education. 2013. 29:4. pp. 118-126.

Clermont, Christian, Borko, Hilda, & Krajcik, Joesph. “Comparitive study of the pedagogical content know eldge of experienced and novice chemical demonstrators.” 1994. Journal of Research in Science Teaching. 31:4. pp. 419-441.

Lee, EunJin., Brown, Michelle, Luft, Julie A., & Roehrig, Gillian. “Assessing beginning secondary science teachers’ PCK: Pilot year results.” School Science and Mathematics. 2007. 107:2. pp. 418-426.

Loughran, John, Mulhall, Pamela, & Berry, Amanda. “Exploring pedagogical content knowledge in science teacher education.” 2008. International Journal of Science Education, 30:10. pp. 1301-1320.

Luft, Julie A. “Beginning secondary science teachers in different induction programmes: The first year of teaching.” International Journal of Science Education. 2009. 31:17. pp. 2355-2384.

Luft, Julie A. “Changing inquiry practice and beliefs? The impact of a one-year inquiry-based professional development programme on the beliefs and practices of secondary science teachers.” 2001. Internation al Journal of Science Education. 23:5. Pp. 517-534.

Luft, Julie A., Firestone, Jonah, Wong, Sissy, Adams, Krista, Ortega, Ira, & Bang, EunJin. “Beginning second ary science teacher induction: A two-year mixed methods study.” Journal of Research in Science Teaching. 2011. 48:10. pp. 1199-1224.

Ortega, Ira, Luft, Julie A. & Wong, Sissy. “Learning to teach inquiry: A study of an early career science teacher who works with English language learners.” School Science and Mathematics, 2013. 113:1. pp. 29-40.

Richardson, Virginia. “The role of attitudes and beliefs in learning to teach.” In John Sikula (Ed.), The handbook of research in teacher education (2nd ed.). Macmillan. New York: NY. pp. 102-119.

Rokeach. Milton. Beliefs, attitudes, and values. Jossey-Bass. San Francisco: CA. 1968.

Shulman, Lee S. (1986). “Those who understand: Knowledge growth in teaching.” Educational Researcher. 1986. 15:2. pp. 4-14.

Shulman, Lee S. “Knowledge and teaching: Foundation of the new reform.” Harvard Educational Review. 1987. 57:1. pp. 1-22.

Simmons, Patricia, et al. “Beginning teachers: Beliefs and classroom actions.” 1999. Journal of Research in Science Teaching. 36:8. pp. 930-954.

van Driel, Jan, Beijaard, Douwe, & Verloop, Nico. “Professional development and reform in science education: The role of teachers’ practical knowledge.” Journal of Research in Science Teaching. 2001. 38:2. pp. 137-158.

van Driel, Jan, de Jong, Onno, & Verloop, Nico. “The development of preservice chemistry teachers’ pedagogical content knowledge.” Science Education. 2002. 86:4. pp. 572-590.