The Factors that Affect Science Teachers' Participation in Professional Development

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Dedication

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In Memory of A. P.

Twenty years ago you were taken away.

But the pain is as strong as if it was yesterday.

It hurt me so,

That you couldn't help me with things I wanted to know.

You couldn't teach me right from wrong,

When I was weak, you couldn't be strong.

While your life was done,

Another had just begun.

You would be proud of her dad,

She is going to be a college grad.

I wish there was a way to let you know,

We're all getting by and that

you have six grandchildren who are really beginning to grow.

Here's to the man I'll never really know,

Dad I still miss you so!

Philip Arthur Chenevert II

It's been almost 15 years since you've all been gone,

Like your examples, I've managed to carry on.

I wish you could be here to share in the glory,

But I will be satisfied to convey the story

Of how the values and knowledge you instilled in me,

Have enabled me to complete this doctoral degree.

Love, Judi Ann

Abstract

Scientific literacy for our students and the possibilities for careers available in Science, Technology, Engineering, and Mathematics (STEM) areas are important topics for economic growth as well as global competitiveness. The achievement of students in science learning is dependent upon the science teachers' effectiveness and experienced science teachers depend upon relevant professional development experiences to support their learning. In order to understand how to improve student learning in science, the learning of science teachers must also be understood. Previous research studies on teacher professional development have been conducted in other states, but Minnesota science teachers comprised a new and different population from those previously studied. The purpose of this two-phase mixed methods study was to identify the current types of professional development in which experienced, Minnesota secondary science teachers participated and the factors that affect their participation in professional development activities. The mixed-methods approach s utilized an initial online survey followed by qualitative interviews with five survey respondents. The results of the quantitative survey and the qualitative interviews indicated the quality of professional development experiences and the factors which affected the science teachers' participation in professional development activities. The supporting and inhibiting factors involved the availability of resources such as time and money, external relationships with school administrators, teacher colleagues, and family members, and personal intrinsic attributes such as desires to learn and help students. This study also describes implications for science teachers, school administrators, policymakers, and professional development providers. Recommendations for future research include the following areas: relationships between and among intrinsic and extrinsic factors, science-related professional development activities within local school districts, the use of formal and informal professional development, and the needs of rural science teachers compared to urban and suburban teachers.

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Chapter 1. Introduction to the Study

Background of the Study

Increasing scientific literacy continues to be a high priority for national organizations, governmental agencies, research entities, and corporate interests. In 1996, the National Research Council defined scientific literacy in the National Science Education Standards to include science content knowledge as well as "understanding the nature of science, the scientific enterprise, and the role of science in society and personal life" (p. 21). Scientific knowledge can lead to a wide variety of careers in the STEM fields (science, technology, engineering, and mathematics). Science and engineering jobs support the local, state, and federal economy with fast growth rates as well as relatively low unemployment levels (National Science Board, 2012). Well-publicized reports and national initiatives explained the importance of science careers and scientific knowledge for the economic future and global competitiveness of the United States, as well as for current issues of national security (Committee on Prospering in the Global Economy of the 21st Century, 2005; U.S. Department of Education, 2000). The level of scientific literacy present in the American populace largely depends upon the scientific education that students received in their preschool through high school years.

The science education that students receive is dependent upon the effectiveness of their science teachers. Highly effective teachers are considered an important connection to student achievement (Business-Higher Education Forum, 2007; Marzano, 2003; Wei, Darling-Hammond, Andree, Richardson, & Orphanos, 2009). According to the Business-Higher Education Forum (2007), research findings have "established that the quality of

P-12 mathematics and science teaching is the single most important factor in improving student performance in these disciplines" (p. 4). Effective science teachers should have content knowledge based in scientific disciplines, as well as pedagogical content knowledge in understanding how to teach science to students who may learn science in different manners (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010; National Research Council, 1996).

Science teachers may achieve their knowledge through various routes on their educational career path. Students may enroll in traditional, preparatory programs at colleges or universities that include both science and education coursework. Scientists or other science professionals may obtain teaching licenses through alternative routes such as accelerated licensure programs or portfolio processes for content experts. Once science teachers have received their licenses and accepted a teaching position, they may continue their education through professional development in formal or informal activities. Formal professional development could include college or university coursework, as well as workshops, institutes, or conferences (Eraut, 2004; Garet, Porter, Desimone, Birman, & Yoon, 2001; Little, 1993; Loucks-Horsley et al., 2010). Informal professional development may consist of less formal, more opportunistic activities such as collegial sharing about peer observations or student work samples, and personal reading or classroom experimentation (Eraut, 2004; Lohman, 2000). Schroeder, Scott, Tolson, Tse-Yang, and Yi-Hsuan (2007) explained that professional development is important for scientific literacy reforms. With the introduction of a new science framework for K-12 education, the implementation of these new standards will require that "the initial preparation and professional development of teachers of science will need to change" (National Research Council, 2012, p. 255).

Secondary science teachers also have specialized needs compared to elementary school teachers. The narrow focus of NCLB reforms on reading and mathematics requirements has led to reduced time for science lessons (Marx & Harris, 2006). If elementary students have fewer experiences with inquiry-based learning, they may have reduced interest in science and future scientific careers (Marx & Harris, 2006). Secondary science teachers would then require more knowledge about sparking student interest in science and providing an introduction to inquiry-based science learning (Griffith & Scharmann, 2008; Marx & Harris, 2006).

The professional development needs of science teachers in rural or small districts may also be different from teachers in larger, metropolitan districts. Rural science teachers are more likely to teach outside of their content area and have an undergraduate major in general science education rather than a degree in a specific discipline of science (Carlsen & Monk, 1992; Monk, 2007). Such teachers would benefit from professional development activities that provide more science content-related learning (Berns, Century, Hiles, Minner, & Moore, 2003). Although class sizes may be smaller, teachers may encounter wider ranges of student needs, especially at the high school level where multiple science disciplines may be taught by only one teacher (Monk, 2007). Pedagogical content knowledge to assist teachers in differentiating instruction in a variety of science content areas is essential (Monk, 2007).

Science reform efforts also call for specific knowledge and scientific strategies. Inquiry-based pedagogy has been introduced and reintroduced at various times throughout the history of American education with the most recent resurgence occurring in the 1990s standards-based reform efforts (Supovitz, Mayer, & Kahle, 2000). In addition to inquiry, current reform measures also discuss the understanding of the nature of science and engineering, as well as the use of constructivist strategies such as discrepant events and addressing student misconceptions (National Research Council, 1996). Most teachers were taught in classroom environments with an emphasis on fact memorization with teacher-led lecturing and would benefit from practical professional development experiences that incorporate these new types of learning opportunities (Garet et al., 2001). Supovitz and Turner (2000) found "a strong relationship between high quality professional development and the kinds of teaching practices that are advocated by science reformers" (p. 976).

High quality professional development offered in structured environments should be utilized to scaffold teacher learning. Teachers need support in their effort toward quality and success (Wei, Darling-Hammond, & Adamson, 2010). The components of high quality professional development include activities that are sustained, intensive, related to classroom practices, focused on content and pedagogical content knowledge, collaborative, and connected to other aspects of school reform (Darling-Hammond & Richardson, 2009; Loucks-Horsley et al., 2010; Wei et al., 2009). Supovitz and Turner (2000) combined several research studies to define the necessary components for high-quality professional development for science teachers to also include inquiry, concrete tasks, experiential learning, and connections to school change. In addition, the high quality professional development opportunities available in collaborative learning settings were positively correlated with student achievement (Gruenert, 2005).

Teachers at various points in their careers need differentiated types of high quality formal professional development. Newly licensed teachers participate in mentoring or teacher induction programs to assist them in acclimating to the situations in school and classroom environments for better teacher retention (Loucks-Horsley et al., 2010). Science content experts who have achieved licensure through alternative routes may request more pedagogical content knowledge such as how to teach and, specifically, how to teach science (Business-Higher Education Forum, 2007). Experienced teachers still require new science content to remain current on emerging scientific discoveries and also need professional development activities that renew their enthusiasm for science teaching (Banilower, Cohen, Pasley, & Weiss, 2010; National Research Council, 1996). Supovitz, Mayer, and Kahle (2000) found that teachers who participated in very intensive inquiry-based professional development had changes in attitude about reform efforts and their own practices which continued for several years after the initial exposure to the inquiry strategies. Effective professional development that provides more than deficit model training may be able to provide revitalization for continuing, experienced teachers that are an essential piece to the student performance puzzle (Huberman & Guskey, 1995).

In addition to the effects on student achievement, professional development is a beneficial component to support district goals and school reform efforts (Bransford, Brown, & Cocking, 1999; Guskey & Huberman, 1995). Many reform efforts include professional development as a vital component to the program process and sustainability, but participation should be voluntary and not mandated (Elmore, 2008; Fullan, 1993). With increased class sizes and reduced resources (time, money, space, or materials), teachers need to learn skills to promote their own continued learning and enhance professional growth in the wake of such limitations (Petrinjak, 2010).

As well as the national requirements for highly qualified content area teachers, states vary in the additional requirements for teacher qualifications. Minnesota science teachers must complete ancillary requirements to receive their licensure. As well as being content experts, the roles of Minnesota science teachers are being expanded and transformed to include the skills necessary for assessment, differentiation, technical reading, and mental health awareness. In addition to science knowledge, current teachers in Minnesota will also need to be well-versed in reading strategies to help students with technical reading in scientific realms (Minnesota Department of Education, 2012e). Beginning in July of 2012, teachers who are renewing their licenses must prepare an evidence-based reflective statement assessing their professional growth (Minnesota Department of Education, 2012e). By 2014, all teachers in Minnesota will be evaluated according to a professional review model based on the Minnesota Board of Teaching Rule 8710.2000, Standards of Effective Practice (Franklin, 2012). Professional development participation assists teachers in enduring and succeeding with these new roles and responsibilities (Little, 1993; Schibeci & Hickey, 2004).

Most teachers do participate in some type of professional development over the course of the school year. Data from the Schools and Staffing Survey, including levels of professional development participation, were used to compile the Science and Engineering Indicators Report for even numbered years. About three-fourths of the science teachers responding to the survey participated in content-related professional development (National Science Board 2008, 2010, 2012). Professional development sessions related to the use of computers in the classroom were also highly attended by science teachers, while professional development participation for discipline or classroom management purposes was much lower.

The Science and Engineering Indicators of 2008 was a more comprehensive report than those from later years (National Science Board, 2010, 2012). The 2008 report reviewed science teacher professional development according to content focus, duration, collaborative practice, format of delivery, as well as usefulness. Science teachers participated in content-related activities for longer periods of time and also considered such sustained activities more useful (National Science Board, 2008). The majority of science teachers attended workshops (91%), while less than half participated in university courses for teaching (37%) or in research activities (38%). A very small number (16%) of science teachers participated in collaborative site visits or observations at other schools.

The research on teacher learning is still progressing. Teacher learning research requires more evidence about teacher learning needs, how that learning can best be facilitated, and the influential factors involved with teacher learning and professional growth (Ball, 2002; Bransford et al., 1999; Garet et al., 2001; Scribner, 1999). Although professional development participation may not directly translate to teacher learning, it is a relevant step in that process (Higgins, 2006; Kwakman, 2003). Numerous studies have shown that participation in high quality professional development promotes changes in classroom and instructional practices which improves student achievement (Borko, 2004; Darling-Hammond & Richardson, 2009; Garet et al., 2001; Supovitz & Turner, 2000; Wei et al., 2009, 2010). Pedder (2007) proposed that understanding more about the individual constraints and beliefs related to professional development opportunities in schools is necessary to improve teacher learning. In addition, the National Research Council (2012) in the recently released K-12 Science Frameworks suggested that "the research base needs further evidence from studies across K-12 teachers at different grade levels and across different disciplines" (p. 257) about the various approaches used for science teacher professional development. In order to encourage teacher learning that will ultimately result in positive changes in student achievement, more information is required about the learning needs and desires of science teachers to actively participate in high quality professional development opportunities.

To determine whether teachers will seek or avoid professional development, policymakers and teacher learning facilitators need to better understand "the complex interplay of personal and contextual factors" (Schibeci & Hickey, 2004, p. 124) involved in their decision-making processes. Higgins (2006) explained that "we should begin by understanding the factors that influence teachers' initial decision not only to attend but also to actively participate in the experience" (p. 2). Wan and Lam (2010) advocated that professional development providers should better understand the needs of teacher learning opportunities in order to make the learning environments more hospitable and productive. In addition, knowledge about the current programs being offered in formal settings will assist stakeholders and professional development providers in creating better systemic approaches to support teachers' and students' needs (Ball, 2002; Schibeci & Hickey, 2004; Wei et al., 2009).

Accessibility and incentives for participation are among the factors influencing involvement in professional development (Kwakman, 2003; Schibeci & Hickey, 2004; Scribner 1999). These factors are affected by state requirements and policies regarding professional development. Influenced by the federal requirements of the No Child Left Behind policies, changes have also been made regarding the Minnesota statutes related to professional development. In July 2005, the Alternative Teacher Professional Pay System (ATPPS) which is more commonly known as Q-Comp was established (MDE, 2011). Q-Comp promoted job-embedded professional development opportunities that were connected to district goals based on student achievement data from high-stakes testing in reading and mathematics. Teachers who participated in the evaluation and school improvement processes would receive differentiated levels of monetary compensation. According to the Minnesota Department of Education (2011c), 52 school districts and 56 charter schools were implementing Q-Comp during the 2011-2012 academic year. The majority of schools involved were from metropolitan and suburban districts, as well as larger population centers in out-state Minnesota (Minnesota Department of Education, 2011c). Following the creation of Q-Comp, in 2009, Minnesota statute 122A.61 stipulating staff development revenue was altered. The opportunity to suspend the requirement to reserve two percent of the general fund for professional development activities had been extended to all districts–a situation that had previously been only for districts in statutory operating debt (SOD) or those districts where a majority vote of teachers agreed to so. The moratorium on reserved professional development funds will end in fiscal year 2013, but a more recent change in the statute eliminated the differentiated funding allocation for individual school sites (J. Alswager, personal communication, July 6, 2012). Over the past decade in Minnesota, statutory opportunities and requirements for classroom teachers' professional development have experienced a variety of changes.

Statement of the Problem

Several research efforts have attempted to obtain more information about the factors affecting teacher participation in professional development. Scribner (1999) described personal, school level, and district level factors that affected participation in various ways. Kwakman (2003) performed a mixed methods study to discover the factors affecting the participation of teachers in professional development opportunities regarding a specific school reform in the Netherlands and clustered the teacher responses into three categories: Personal Factors, Task Factors, and Work Environment Factors. Higgins (2006) combined Kwakman's (2003) factors with the decision issues related to the Dimensions of Autonomy discussed by Schibeci and Hickey (2004) for a revised model suggesting that the categories of factors are interrelated and influence one another. Based on Kwakman's (2003) research, Wan and Lam (2010) performed a case study with teachers in Hong Kong participating in continued professional development related to a newly instituted reform effort, but included the possibility of a family factor not included in the Netherlands study. Studies regarding the factors affecting science teachers' participation in professional development have been performed in the Netherlands, China, and states such as Texas and California, but a similar study has not been performed in Minnesota. According to Wei et al. (2010), Minnesota exhibited four of eight professional development indicators in the report ranking the professional development access of teachers in all states, while Arkansas exhibited seven of eight indicators. The effects of the modified statutory opportunities and requirements for teacher professional development on the levels of teacher participation in high quality professional development have not been studied in Minnesota. Participation in professional development opportunities would be an avenue for science teacher learning that would ultimately affect student achievement levels in science. Since Minnesota and Arkansas teachers differed in their access to high quality professional development indicators, a logical argument would be that Minnesota science teachers comprised a new and different population from those previously studied. Thus, there was a need to understand the professional development activities in which Minnesota science teachers have engaged and the factors that affected their participation in those professional development activities.

The Purpose Statement

The purpose of this two-phase mixed methods study was to identify the current types of professional development in which experienced, Minnesota secondary science teachers participate and the factors that affect their participation in professional development activities. In the first phase, quantitative research questions addressed the descriptions of the types (high quality, formal, informal) and formats (workshops, school in-services, individual explorations) in which professional development was experienced for general education, as well as science-related topics. The quantitative portion also sought to discover the various levels of intrinsic and extrinsic factors that positively or negatively influenced the participation of the science teachers by listing factors described by the literature review research studies. In the second phase, qualitative interviews were performed with willing survey respondents at various stages in an experienced teaching career to ascertain a more detailed description of their personal experiences with professional development outside of and within their own school districts.

Research Questions

1. In what types of professional development do experienced, highly qualified, secondary science teachers in Minnesota engage?
2. What factors influence their decision to participate in any type of professional development activities?
    a. What intrinsic factors promote participation?
    b. What intrinsic factors inhibit participation?
    c. What extrinsic factors promote participation?
    d. What extrinsic factors inhibit participation?
3. How do experienced, secondary science teachers describe the factors that affect their professional development experiences?

Importance of the study

Although the student enrollment in American classrooms has increased, achievement and college graduation rates in STEM subject areas continue to be low compared to other developed countries. In the United States, only 32% of college graduates received a science or engineering degree compared to 66% in Japan, 59% in China, and 36% in Germany (Committee on Prospering in the Global Economy of the 21st Century, 2005). In a more recent study, the statistics listed in an *NSTA Reports* article by Petrinjak (2010), placed the American STEM graduates at an even lower level of only 15% compared to the 55% of Chinese STEM graduates. Despite the push for increased American scientific knowledge, the current statistics for U.S. scientists are of great concern to many stakeholders and ensuring effective science teachers is a recommended component to remedy the levels of STEM graduates.

In addition to effective science teachers with the proper background knowledge, ensuring sufficient numbers of these highly-qualified science teachers is another important facet. In 2000, the United States Department of Education warned of the increasing shortage of qualified science and mathematics teachers in the United States. In more recent years, states reporting their areas of teacher shortages continually list science as a high-need field for qualified teachers (U. S. Department of Education, 2011). Despite the qualification requirements of No Child Left Behind legislation, many science and mathematics classes are currently taught by instructors outside of the necessary content area (Ingersoll & Perda, 2010). The Business-Higher Education Forum (2007) suggested three main elements to ensure the supply of future science teachers:

recruitment, retention, and renewal (p. 5). Recruitment involves better teacher preparation programs and alternative routes to teacher certification for content experts. Retention relates to strategies for keeping newly hired college graduates as well as experienced teachers. Renewal includes professional development as well as programs that assess teacher quality and student outcomes (Business-Higher Education Forum, p. 4). However, Ingersoll and Perda (2010) suggested that the supply of pre-service teachers should be sufficient to fill our need for qualified science teachers, but the shortage of teachers is actually due to experienced teachers leaving the teaching field. While new teacher induction processes have been more successful, effective professional development efforts for experienced teachers have actually been regressing (Wei et al., 2010). Therefore, understanding the needs of experienced science teachers for professional development will encourage high-quality opportunities focusing on retention and renewal at the local school level, providing better uses for additional STEM education funding (Burke & McNeill, 2011).

Although schools typically set aside only a small amount of their budget (1-3%) for professional development as compared to corporate employers (Bransford et al., 1999), policymakers and other community stakeholders want to ensure that their expenditures are cost-effective (Loucks-Horsley & Matsumoto, 1999). Other nations, our global competitors, set aside many resources such as money and time for their educators to be involved in high quality professional development efforts (Wei et al., 2010). In Minnesota, statute 122A.61 directs the spending of school district professional development funds, but schools in statutory operating debt (SOD) were not required to set aside funds for teacher professional development and a moratorium on set-aside requirements for all districts was imposed for the academic years of 2009-2013. Currently, school district funds already reserved in professional development categories are carried over, but everything is placed in a general budget with no percentage requirements according to individual school sites. Mizell (2010) explained that investing in a community's education system through professional development and other elements of school reform will return to support that community's economy. With the increased scrutiny of professional development outlays, understanding the details (how, when, and why) teachers participate and experience professional development will help maximize the benefits of teacher learning in order to improve teacher practices and student achievement (Loucks-Horsley & Matsumoto, 1999; Schibeci & Hickey, 2004).

Understanding professional development participation will also provide feedback to policymakers and professional development providers to promote programs which increase the coherence and reduce discontinuity between proposed policies and actual classroom practices (Garet et al., 2001; Schibeci & Hickey, 2004; Wei et al., 2009). Science teachers are also concerned about the discontinuity between educational policies and classroom practices. A member poll published by the National Science Teachers Association about the state of science education yielded responses from over 400 science teachers (NSTA Reports, 2012). Over half of the respondents reported that science, as a subject, is considered less important now than it was two decades ago. Furthermore, 58% of the science teacher respondents stated that their professional development opportunities in science-related activities are inadequate. In addition, Wei et al. (2009)

reported that American teachers do not find the available professional development to be useful or effective. Although the National Science Board (2012) reported that 77% of the science teachers participated in professional development activities related to the content of their teaching discipline, 24% of the science teacher respondents also listed professional development related to their primary subject area as a top priority for continued focus. Previous studies have described the past participation of science teachers in professional development activities and their desires for future professional development opportunities. However, these studies did not explain the reasons behind their decisions to participate or not participate and whether they are participating in the areas of professional development designated as a top priority. The description of current professional development programs and the factors affecting participation in this study will assist in improving the infrastructure for district or state professional development programs (Schibeci & Hickey, 2004; Wei et al., 2009).

Definition of Terms

Highly qualified teacher–in Minnesota, a teacher who has an academic major in their area of teaching licensure or who has passed the appropriate content examination for teacher licensure (Minnesota Department of Education, 2012d)

Secondary science teacher–an individual licensed to teach any discipline of science (general, earth and space, life, or physical) to students in grades five through twelve.

Continuing, experienced teacher–an individual who has held a teaching position for five or more consecutive years. (Hoekstra, Brekelmans, Beijaard, & Korthagen, 2009, p. 665).

Professional development–"any activity that develops an individual's skills, knowledge, expertise and other characteristics as a teacher" (Organisation for Economic Co-operation and Development, 2011).

Formal professional development–structured activities such as workshops, conferences, institutes, or post-secondary courses that occur in a formal setting

Informal professional development–structured or unstructured activities that occur in less formal settings, are usually self-initiated, and include lesson study groups, peer coaching, or collegial conversations (Lohman, 2000, 2003, 2006)

High quality (or effective) professional development components–High quality or effective professional development is based on clear goals; sustained; intensive; collaborative; connected to classroom practices; involves active learning; and tied to other aspects of school reform efforts.

Rural district–School districts with fewer than 10 students per square mile (McMurry & Ronningen, 2011).

Urban schools–In Minnesota, schools located in Minneapolis and St. Paul (Hare & Nathan, 2007).

Suburban schools–Schools located in the seven county metropolitan area of Minnesota not including Minneapolis and St. Paul. (Hare & Nathan, 2007).

Assumptions

Because this study employed a mixed methods approach with an initial quantitative survey presented in an online format and a secondary phase with individual interviews, assumptions were inherent regarding the participant responses. One assumption was that the science teachers would utilize similar definitions for the various types of professional development in their survey responses. A second assumption was that the science teachers would provide candid information and opinions from their own personal experiences with professional development. A final assumption would be that the science teachers would not perceive any negative repercussions for their honest participation in the survey. The participant consent form, specific survey directions, and carefully worded survey questions helped to ensure that these assumptions would be addressed in the study.

Limitations

Dillman (2000) listed several types of errors that may result from a survey design which resulted in limitations for this study: coverage error, sampling error, measurement error, and non-response error. Coverage error occurs when possible respondents are missing from the available participant list. The possibility of coverage error existed because a list of all highly qualified teachers from all grade levels and all content areas was available through the Minnesota Department of Education website, but the actual years of teaching experience was not included as part of the data. Therefore, a true participant list was difficult to compile and some possible respondents may have been missed.

Sampling error results from only surveying a small sample of the population and was inherent in the study because a random sample of science teachers was selected from the total population of secondary science teachers in Minnesota. Because the highly qualified teacher list that was used for the population of science teachers from which to draw the sample was two years old (from the academic year of 2010–2011) and the data did not include years of teaching experience, the true population of experienced, highly qualified science teachers may not have been used.

Survey responses that do not align with other responses create measurement errors. Due to the researcher's inexperience in survey design and pilot testing, as well as the use of the online survey construction software (Qualtrics), measurement error was a potential limitation. Some of the supporting and inhibiting factors described in previous research were so numerous, that the researcher selected some that seemed most common and some of those selections may not have matched the desired responses for the survey participants. In a related fashion, some of the long lists of supporting and inhibiting factors may have resulted in more people selecting the first options rather than reading all of the choices. Measurement error can also occur due to the responding behavior of the survey participant. Thus, this self-reporting questionnaire produced results based on the individual's perception of themselves and their experiences with professional development, as possible measurement error.

Non-response error results from the possibility that non-respondents would have given different answers regarding their professional development experiences than the answers from the actual respondents. Since the initial pre-notice contacts were delivered to randomly selected participants in an email message, the probability existed that the message could be deleted or filtered to a spam folder without being read which would create non-response error. Because the link to the online survey was also delivered by email after the initial pre-notice, the probability existed that only a small amount of those emails were actually read. The questionnaires also had to be completed and be completed correctly. People with more of a vested interest in professional development and their own personal growth as a science teacher might have been more likely to respond which would affect the actual results received and analyzed. The small response rate and the specific population being studied (experienced, secondary science teachers in Minnesota) may not be widely generalized to other populations because of unique geographic and cultural characteristics.

Creswell (2009) described limitations with interviews that were applicable to this study. Interview information was filtered through the individual professional development experiences of the interviewees. The researcher's presence and known occupation as a science teacher may have biased the responses of the interviewees. The interviews usually occurred in situations and environments outside of the natural setting for professional development activities. Additionally, a related limitation for the interviews was the researcher's lack of experience with the Zoom H4N audio recording equipment that may have resulted in missed statements by the interviewed science teachers not captured by the note-taking procedures.

Another possible limitation for this research study included the careers of the researcher as a science teacher and as a professional development facilitator. Preconceptions about possible survey answers and interview responses most likely affected how the survey and interview questions were created, as well as how the data were analyzed and interpreted. The researcher reviewed a previously written identity memo as suggested by Maxwell (2005) relating to personal teaching and professional development experiences to assist in the self-awareness of the preconceptions for better bracketing.

Despite these limitations involved with errors, the combined survey and interview method were easily implemented by the researcher without further complications. Qualtrics software was available to the researcher as a student without additional costs and offered detailed user's guides for the logical use of the survey design components. The interviews went smoothly once they were scheduled and conducted. Finally, the individual email links made the survey convenient for all respondents to access and for the researcher to track responses.

The Nature of the Study

A mixed-methods approach that collected both quantitative survey data and qualitative interview data from science teachers about their professional development experiences was utilized for this study. The idea for mixing quantitative and qualitative research methods has been suggested since the late 1950s, but the strategy for using one type of research method to connect with or to inform the other research method became much more common in the 1990s (Creswell, 2009). Eisner (1991) suggested that "educational inquiry will be much more complete and information as we increase the range of ways we describe, interpret, and evaluate the education world" (p. 8). The current consensus suggests that "qualitative and quantitative research can complement each other" (Gall, Gall, & Borg, 2007, p. 32). The combination of these two research methods "can provide richer insights and raise more interesting questions for future research" (Gall et al., 2007, p. 32).

Although the research methods were designed concurrently, the data collection occurred in a sequential manner with the interview participants selected from the willing survey respondents. The reason for combining quantitative and qualitative methods for this study was to converge the survey findings of frequency counts and percentages with personal descriptions from the lived experiences of Minnesota science teachers. In these modern days of data-driven decision-making in schools, all teachers (including science teachers) are very familiar with quantitative data and statistics. Interviews, on the other hand, are “a powerful resource for learning how people perceive the situations in which they work” (Eisner, 1991, pp. 81-82). This mixed-methods research study triangulated the findings of the quantitative survey data and the personal accounts of qualitative interview data to provide a more comprehensive view of the professional development activities of science teachers and the factors that support or inhibit their professional development participation.

Summary

In this chapter, background information discussed the impact that high quality professional development in science content and pedagogy has on teacher learning and growth which ultimately affects the scientific knowledge and skills of our nation’s youth. The purpose of the mixed methods research undertaken for this study attempted to describe the current professional development experiences of highly qualified, secondary science teachers in Minnesota and the factors that support or inhibit their participation in professional development opportunities.

Chapter 2 contains the literature review. The first sections discuss the definitions and purposes of professional development. The following sections explain the components of high quality professional development and adult learning principles. Professional development participation and the factors affecting participation were included in the next sections. Finally, professional development specific to science teachers and the characteristics of science teachers conclude Chapter 2.

Chapter 3 elucidates the mixed methods research methodology and design for the processes involved with participant selection and instrument development, as well as data collection and analysis.

In Chapter 4, the resulting quantitative survey data and the qualitative interview data are presented.

Chapter 5 provides a detailed summary of the findings along with implications of this study for various stakeholders and recommendations for further study.

Chapter 2. Literature Review

The Definition of Professional Development

The concept of professional development for teachers has undergone many transformations in name and meaning since its first inception. During the Victorian era, teacher learning was encouraged on a personal level for educational reading and getting to know students better in order to work toward a more student-centered environment (Larsen, 2002). Formal teacher professional development has been utilized in American school systems since the 1800s with the advent of Teacher Institutes (Guskey, 1986). After World War II, the focus was on reforming curricular materials (Wideen & Andrews, 1987). In the mid-twentieth century, professional development was considered “staff development” and mainly consisted of workshops or in-services attended by large groups of teachers. Such sessions became the norm to improve teacher knowledge and skills which may not have been acquired during their pre-service education and student teaching experiences. The professional development in-services of the 1960s held within the school were used to demonstrate "teacher-proof curricula" which often resulted in curricular implementations that were not sustainable (Lieberman & Miller, 1990; Supovitz, Mayer, & Kahle, 2000; Wideen & Andrews, 1987). Guskey (1995) suggested that, for new and inexperienced teachers, their initial professional development sessions have remained essentially the same for the past 50 years, consisting of school protocol explanations rather than instructional methods or classroom management techniques. Mizell (2010) explained that over the years several terms have been used synonymously with professional development including "staff development, in-service, training, professional learning, or continuing education" (p. 5). However, as the new millennium unfolded, "professional development" emerged as the preferred expression to focus on the professionalism of teaching (Eraut, 1995). Just as other professions engage in educational experiences to enhance their work, educators also participate in professional development activities to promote student achievement (Mizell, 2010; National Research Council, 1996).

More recent definitions of professional development integrate multiple aspects of workplace learning. The Organisation for Economic Co-operation and Development (2011) defined professional development as "any activity that develops an individual's skills, knowledge, expertise and other characteristics as a teacher" (p. 44) including personal study, reflection, collaborative development, and formal courses. The new definition promoted by the National Staff Development Council explained that professional development is "a comprehensive, sustained, and intensive approach to improving teachers' and principals' effectiveness in raising student achievement" (Hirsch, 2009, p. 12). Although the general use of the term professional development implies a formal program utilizing workshops and in-services, professional development can also occur in informal contexts such as collegial dialogues, peer observations, or personal readings (Mizell, 2010). Fullan (1995) defined professional development as "the sum total of formal and informal learning pursued and experienced by the teacher in a compelling learning environment under conditions of complexity and dynamic change" (p. 265). A more comprehensive definition offered by the American Federation of Teachers (2008) called professional development "a continuous process of individual and collective examination of practice" (p. 3) that includes empowerment for decision-making, problem solving skills, and the use of research-based classroom practices to improve student achievement. Along with the new definition of the term professional development, the National Staff Development Council proposed a new ideal of professional development that expects "every educator to engage in professional learning at the school as part of the workday" (Hirsch, 2009, p.10).

Just as the definition of professional development has undergone many changes, different approaches as to what may be considered professional development have also evolved. Job-embedded professional development in the context of the workplace involves the learning that occurs as school personnel function in their daily work lives (Wood & McQuarrie, 1999). Such workplace learning can be classified as formal or informal learning experiences (Lohman, 2006). Formal workplace learning typically consists of specific programs, workshops, conferences, or continuing education coursework. Such activities are considered the epitome of professional development opportunities by school board members and the district personnel office (Killion, 2002). In addition, Wei, Darling-Hammond, Andree, Richardson and Orphanos (2009) reported that nine out of ten U.S. teachers experience their professional development as formal activities such as workshops and conferences. Huberman and Guskey (1995) described many formal activities as deficit models of teacher learning. Many formal activities may occur as mandated training intended to improve teacher knowledge or skills and are based on the assumption of teacher incompetencies. Fullan (1995) explained that formal learning such as workshops can provide insight and introductions to new knowledge and skills. However, other opportunities should extend the professional learning that was ignited by those formal activities (Boyle, While, & Boyle, 2004).

Informal learning opportunities may function as a continuation of the learning begun in a more formal, structured activity or be completely self-directed and separate from formalized learning. Lohman (2000) defined informal learning as those "activities initiated by people in work settings that result in the development of their professional knowledge and skills (Lohman &Woolf, 1998; Watkins & Marsick, 1992)" (p. 84). Lohman (2000) also explained that "informal learning can be either planned or unplanned and structured or unstructured" (p. 84). Informal activities such as collegial conversations or examining samples of student work are also the most often requested by teachers for the practical application of such learning (Killion, 2002). Informal learning offers more opportunities for personal teacher inquiry and collaborative models of learning (Lohman, 2006).

The modern definition of professional development encompasses more than workshops and in-service trainings. Mizell (2010) discussed the engagement of "teams of teachers to focus on the needs of their students" as the most effective professional development (p. 1). Sparks and Loucks-Horsley (1989) described five models of staff development which are now more commonly referred to as professional development activities: 1) individually-guided staff development such as reading, reflection, and classroom visits as well as personally selected workshops; 2) observation and assessment processes performed by peers or supervisors that include pre- and post-observation conferences and data analysis; 3) involvement in a curriculum development or organizational improvement process that involves further knowledge and skill acquisition; 4) training such as expert-led workshops that are often decided by administrators and is most often considered synonymous with staff development; and 5) teacher inquiry such as that involved with action research or lesson study. *Powerful Designs for Professional Learning* edited by Easton (2004) also describes other professional development opportunities such as student focus groups and shadowing, whole faculty study groups (WFSGs), critical friends groups (CFGs), tuning protocols, journaling, teacher portfolios, and visual dialogue that provide a much broader range of workplace learning possibilities. The value of a buffet of activities for teacher professional growth gains more recognition in leadership circles as the utilization of reform type activities increase. For example, beginning in the summer of 2012, the state of Minnesota will require evidence of reflective practice for teacher relicensure applicants in addition to the typical trainings and courses completed for continuing education credits (Minnesota Department of Education, 2011a).

What American teachers experience as professional development runs counter to the research findings for the established qualities of true effectiveness (Loucks-Horsley & Matsumoto, 1999; Wei, Darling-Hammond, & Adamson, 2010). In 1977, Zigarmi, Betz, and Jensen reported that teachers found in-services and short-term workshops to be the least helpful form of professional development. Yet, Wei et al. (2009) reported that workshops are still the most common professional development activities for teachers. In addition, the one-stop workshops are typically led by experts who lecture to passive teacher participants about seemingly impractical topics (Boyle, While, & Boyle, 2004;

Darling-Hammond &Richardson, 2009; Dillon-Peterson, 1981; Little, 1993; Sparks & Loucks-Horsley, 1989). Garet et al. (2001) stated that professional development employing multiple high quality components from the structural features (form of professional development activities, duration, collective participation) and core features (content focus, active learning, coherence as part of a program) are more costly for school districts in terms of planning time and monetary expenditures. These resource outlays are typically much more than districts are willing or able to spend, which encourages the use of workshops and in-services that are considered more cost-effective in terms of resource usage. However, teachers that participated in extensive hours of high quality professional development each year rated their activities at higher levels of effectiveness (Wei et al., 2009).

The Purposes of Professional Development

The primary purpose of professional development to promote student achievement has remained relatively unchanged over the years. High quality professional development should affect teaching practices which, in turn, should help to improve student achievement (Garet et al., 2001; Guskey, 2002; Supovitz & Turner, 2000). High quality professional development is especially important as the responsibilities of classroom teachers continue to expand and change to include knowledge and skills beyond general content and pedagogy. Teachers are expected to be experts in standards for curriculum and teaching practices, as well as in decision-making processes for leadership roles (Lohman, 2006; Schibeci & Hickey, 2004; Scribner, 1999). Wei et al. (2010) explained in the NSDC report on the trends and challenges of American professional development that teacher quality is an important factor in student achievement and that such quality can be fostered by effective professional development. Hirsch (2009) reported the importance of professional development in addressing "the inequities in teaching quality and educational resources" (p. 11). Sparks (2002) described the National Staff Development Council's purpose for staff development as "high levels of learning and performance for all students and staff members" (Foreword). Guskey (1986) proposes that "staff development programs are a systematic attempt to bring about change-change in the classroom practices of teachers, change in their beliefs and attitudes, and change in the learning outcomes of students" (p. 5). In addition, Mevarech's (1995) educational growth includes changes in "teachers' mental models, beliefs, and perceptions regarding children's minds and learning" (p. 152). Finally, Fullan (1995) suggests that professional development is essential "to accomplishing moral purpose, as central to continuous improvements in professional work cultures, and as embedded in the continuum of initial and career-long teacher education" (p. 265).

Professional development is also essential to school reform efforts. No Child Left Behind legislation required that high quality professional development be made available to all teachers (Borko, 2004). However, effective professional development should be part of a larger, sustained school reform effort rather than isolated events (Darling-Hammond & Richardson, 2009). Lieberman and Miller (1990) also promote such a collaborative model of teacher inquiry. Professional development that inspires a positive school climate and reduces systemic frustration should result in increased numbers of effective teachers (Dillon-Peterson, 1981; Hargreaves, 2004; Wideen & Andrews, 1987).

Sparks and Hirsch (1997) explain that numerous reports by "governmental bodies, business groups, and various commissions emphasize the central role staff development must play in school reform efforts" (p. 1). Fullan and Stiegelbauer (1991) suggested that in order to solve problems faced by schools and school districts, a critical eye must first determine the best innovations that will be embraced by the school community. Professional development that increases teachers' content knowledge and the abilities to make connections to student knowledge are vital components for school improvement (Elmore, 2008). The investment of teacher learning through professional development opportunities also helps to attract and retain effective teachers (Scribner, 1999). The Minnesota Department of Education (2011a) also emphasized the importance of effective professional development in conjunction with continuous improvement processes for schools. An integrated approach to professional development discussed by Sparks and Hirsch (1997) is results-driven as well as incorporating systems thinking and constructivism. Professional learning communities use the recommended combined effort linking professional development activities to curriculum, assessment, and communication activities. For example, Project PASS (Preparing All Students for Success) described by Eaker, DuFour, and Burnette (2002) used the following steps in their school processes: 1) purposefully align curriculum, instruction, assessment, and staff development; 2) actively promote a climate of achievement: incentives and celebrations; 3) structure strong parent relationships; and 4) support students who need additional time to learn. (pp. 137-139). Although school reform is interwoven with multiple layers of intricacies, effective professional development is a crucial factor in moving toward successful school reform and continuous improvement efforts.

The Components of Effective Professional Development

Effective or high quality professional development should consist of several components. Research indicates that the most effective professional development includes many of the components described in the previous definitions. Initially, effective professional development must have "a sustained focus on achieving student-learning goals derived from clear and high expectations for all students" (Sparks, 2005, p. 90). Student learning can be positively affected by professional learning that is "sustained over time, focused on important content, and embedded in the work of professional learning communities that support ongoing improvements in teachers' practices" (Wei et al., 2009, p. 7). Easton (2004) characterizes "powerful professional learning" with these attributes: establishing a culture of quality; honoring the staff's professionalism, expertise, experiences, and skills; promoting inquiry and reflection; and ensuring some level of application.

Besides intensive and sustained job-embedded circumstances for learning about new and deeper content knowledge and skills, effective professional development should also include the pedagogical pieces involved in teaching such information to students. Wei et al. (2009) reported that when teachers were supported by intense, long-term quality professional development, student achievement showed greater increases during the subsequent school year. In addition, opportunities to actively practice and apply the relevant knowledge and skills that will be used with students in real-life classroom situations are vital to meaningful professional learning for teachers (Banilower, Cohen, Pasley, & Weiss, 2010; Garet et al., 2001; Guskey & Yoon, 2009; Lieberman & Miller, 1990; Wei et al., 2010). Connecting the professional development to other aspects of school reform such as assessment and standards will ensure the sustainable nature of the activities involved (Darling-Hammond & Richardson, 2009; Elmore, 2008; Garet et al., 2001; Loucks-Horsley et al., 2010; Wei et al., 2010). Individual teacher reflection and collaborative, collegial efforts will extend the professional learning for teachers (Darling-Hammond & Richardson, 2009; Hirsch, 2009; Lieberman & Miller, 1990; Loucks-Horsley et al., 2010; Wei et al., 2010). Finally, evaluating and monitoring the progress of student and teacher learning will provide evidence to direct future professional development activities (Elmore, 2008; Guskey, 1998; Hirsch, 2009; Killion, 2002; Loucks-Horsley et al., 2010). Guskey (1998) recommended five levels of evaluation: 1) Participant Reaction, 2) Participant Learning, 3) Organizational Support and Learning, 4) Participant Use of New Knowledge and Skills, and 5) Student Learning Outcomes to fully appraise the results of professional development.

Adult Learning

The components of high quality professional development also coincide with the learning conditions expected for adult learning. Southworth (1984) as cited in Wideen and Andrews (1987) proclaimed that "staff development is adult learning" (p. 2). Adult learning should be voluntary as opposed to the compulsory education of children (Terehoff, 2002). Adult learning is self-directed with an internal motivation to learn (Brookfield, 1995; Cranton, 1994; Hargreaves, 2004; Imel, 1989; Knowles, 1984; Lieb, 1991; Wlodkowski, 1991; Zemke & Zemke, 1984). However, workshop attendees may consider such formal types of professional development to be compulsory (Cranton, 1994; Terehoff, 2002). Even voluntary learners may not be completely engaged in workshop activities (Cranton, 1994). The type of classroom strategies that are promoted for young learners (wide varieties of engaging activities, based on previous experiences, relating to real-world situations, and collaborative) are often not provided to adult learners (Bransford et al., 2000; Sparks & Hirsch, 1997; Loucks-Horsley et al., 2010).

Adult learners also expect their professional development opportunities to be practical and applicable to their classroom situations (Cranton, 1994; Guskey, 2002; Lieb, 1991). Adult learning is based upon prior knowledge and experiences suggested by the constructivist model of learning (Bransford et al., 2000; Brookfield, 1995; Imel, 1989; Knowles, 1984). Providing constructivist opportunities that value the classroom expertise of teachers would also support the expectations of teachers as adult learners (Easton, 2004; Lieb 1991). Adult learners have specific orientations toward their learning based upon the current situation to be addressed (Imel, 1989; Knowles, 1984; Lieb, 1991; Zemke & Zemke, 1984). The self-determined learning of heutagogy promotes teacher inquiry based on the timeline and direction of the teacher's needs (Hase & Kenyon, 2007).

Teachers, as adult learners, have different expectations for professional development and have life challenges that may affect their participation (Lieb, 1991). Certain factors may affect their desire to learn, as well as the amount of engaged participation in professional development opportunities (Wlodkowski, 1991). The desire to learn may result in increasing knowledge, escaping boredom, or advancing personal goals (Lieb, 1991). Relationships and external expectations may also affect adult learning inclinations (Lieb, 1991). Knowles, Holton, and Swanson (2011) explained that, for adult learners, internal motivations encouraged more learning than external requirements. In addition, “a self-diagnosed need for learning produces a much greater motivation to learn” than externally imposed improvements (Knowles, 1970, p. 284). As Wlodkowski (1991) stated,

> People who possess motivation to learn may find external barriers of circumstance and prejudice - but they are not their own enemies, and they are the most fit to learn ways to overcome such obstacles. They are the most likely to be capable of creativity and excellence because the best in science, scholarship, or art cannot be coerced from an unwilling heart (para. 3).

Professional Development Participation

Teachers have various reasons for pursuing professional development. Little (1993) explained that the main impetus for seeking professional development relates to the actual teaching assignments and experiences of working within a school system. Despite mandatory attendance at compelled training sessions for certification or contractual obligations, the underlying reason for attempting professional development according to Guskey (1986, 2002) is the quest to become a better teacher. Lohman (2003) explained that new teaching tasks, new leadership roles, and district policies and procedures increased the utilization of informal learning processes. Deeper content knowledge and the new pedagogical skills that accompany the pushes for increased diversity, accommodations, and technology usage require more professional learning for teachers at all levels (Little, 1993; Lohman, 2006; Scribner, 1999). Guskey (1984, 2002) reported that teachers who participated in an intensive professional development program and witnessed the resulting change in student outcomes experienced attitudinal changes and were much more content with their teaching experiences. The investment into educator learning was listed as an important element to "attract and retain good teachers" (Scribner, 1999, p. 240). As career experiences working within a school increase, teachers choose to combine classroom professional development with opportunities that may also be helpful or of interest in their personal lives (Scribner, 1999). With the ever-changing roles of classroom teachers “as curriculum designers and implementers, as administrators and assessors, and as the connection between schools and community” (Schibeci & Hickey, 2004, p. 120) effective professional development to supplement teacher growth in these multiples areas is vital.

Factors Affecting Participation

The actual practicality of professional development participation is an overarching consideration for teachers. To determine whether attendance or participation could be accomplished, teachers would utilize appraisals of feasibility (Higgins, 2006; Kwakman, 2003; Scribner,1999). Schibeci and Hickey (2004) presented decision issues such as commitment, compulsion, convenience, enticement, interest, opportunity, recommendation, and relevance that teachers considered prior to professional development sessions. Teachers seem to analyze the cost-benefit ratio. Is the professional development going to be worth the expenditure of time, money, and energy?

Will time better be spent in the classroom, with family or friends, or in a leisure time activity? In the end, the ultimate choice to participate in professional development depends upon the personal characteristics of the teacher (Higgins, 2006; Kwakman, 2003; Lohman, 2003, 2006; Schibeci & Hickey, 2004).

Because teachers perform their duties and their learning in several different contexts, appraisals and decisions about professional development participation may be affected by these contexts. The three main teacher contexts described by Eraut (1994) are the academic context with pre-service teacher preparation, the school context which constitutes the organizational work environment, and the classroom context where the teacher implements the theoretical research from the academic context into actual practice (Scribner, 1999). Loucks-Horsley et al. (2010) listed eight context factors that should be considered when designing professional development: "(1) students and their learning needs; (2) teachers and their learning needs; (3) curriculum, instruction, assessment practices, and the learning environment; (4) organizational culture and professional learning communities; (5) leadership; (6) national, state, and local policies; (7) available resources; and (8) families and the community" (p. 81). In addition, Loucks-Horsley et al. (2010) discussed seven critical issues that influence professional development "(1) building capacity for sustainability, (2) making time for professional development, (3) developing leadership, (4) ensuring equity, (5) building a professional learning culture, (6) garnering public support, and (7) scaling up" (p. 118) to ensure that effective instructional approaches are implemented by all district educators.

The contexts and critical issues address both intrinsic and extrinsic factors that may affect professional development participation. Although the personal and professional lives of teachers often intersect at various points, researchers attempted to categorize factors that may enhance or inhibit teacher participation in professional development. Lohman (2006) based the study of encouraging intrinsic factors and inhibiting environmental factors for informal learning on information gleaned from two previous studies in 2000 and 2003. Scribner (1999) described personal intrinsic and extrinsic factors, as well as school level and district level factors that affect teacher participation in professional development. Kwakman (2003) also discussed personal factors, but included task factors and work environment factors as additional categories. Schibeci and Hickey (2004) did not categorize the factors, but instead explained how combinations of day-to-day particulars with the multiple cross-over of personal and environmental factors affected the decision-making processes of teachers. Higgins (2006) combined the participation factors of Kwakman (2003) with the decision issues of Schibeci and Hickey (2004), resulting in the categories of personal, environmental, and programmatic factors. In the 2006 revised model, Higgins suggested that the personal factors were affected by the environmental and programmatic factors, although this supposition was never tested. Korthagen (2004) described an onion model that discussed the layers of questions involved in the choices for the professional lives of teachers. Eight facilitating and inhibiting factors were tested by Wan and Lam (2010) including personal factor, school factor, financial factor, family factor, time factor, government factor, CPD provider, and relationships with others. The complicated intermingling between the personal and professional lives of teachers, as well as the complex interactions of intrinsic and extrinsic factors all influence professional development participation (Schibeci & Hickey, 2004).

Time.

Lack of time is often listed as an external barrier to participation in professional development or other adult learning (Knight, 2000; Kwakman, 2003; Lohman, 2000; Schibeci & Hickey, 2004; Scribner, 1999; Wan & Lam, 2010). Time can be a precious commodity in the life of a teacher. As teachers consider professional development participation, they look at the total amount of time involved in the endeavor, as well as how time may be reduced for other activities. Being out of the classroom involves preparing plans for substitute teachers and possibly lost instructional time for students if the classroom activities were not effective during the teacher's absence (Lohman, 2000; Schibeci & Hickey, 2004; Wan & Lam, 2010). If the professional development session is at a distant location, travel time needs to be included, which also means time spent away from family, friends, or other obligations (Loucks-Horsley et al., 2010, Schibeci & Hickey, 2004; Scribner, 1999). With larger class sizes, more integration of special needs students, and increased diversity in student populations, teachers are spending more time focused on different classroom management strategies and instructional techniques to help students which may result in reduced informal learning opportunities or content learning applications (Lohman, 2000; Scribner, 1999). As total non-teaching time is reduced because of other district duties (teacher leadership roles or committee work), teachers view professional development, especially informal opportunities, as non-essential aspects to their daily working lives and prefer to stay in their own classrooms (Knight, 2000; Lohman, 2000). Volunteering for other non-teaching roles such as coaching or chaperoning student activities may also be reduced, despite the possible benefits of adding resume-building items or the personal satisfaction that comes from helping students (Lohman, 2000).

Time may also directly or indirectly affect relationships. Time spent in formal professional development sessions (out-of-town or after school) disrupted home schedules and childcare necessities (Schibeci & Hickey, 2004; Wan & Lam, 2010). Class teaching schedules and distant locations from colleagues reduce collaborative opportunities as well as material and resource sharing (Lohman, 2000; Scribner, 1999). As schedules are being created, the collaborative needs of teachers to have common non-teaching time may not be considered (Lohman, 2000).

How time is used within the district may also be an influential issue. Release time may be a positive influence because teachers are not being asked for extra time commitments outside of the school day (Schibeci & Hickey, 2004; Wan & Lam, 2010). However, if the release time is expected to be spent on mandated district training rather than in individual or informal learning activities, teachers may be resentful (Lohman, 2000). In addition, as teachers consider their time use, any time spent in professional development activities means that time will not be spent in leisure activities (Schibeci & Hickey, 2004; Wan & Lam, 2010).

Although time is a consideration for most formal professional development activities, the lack of time can also be a concern for informal professional learning.

Lohman (2000) found that as teachers' responsibilities increased with larger class sizes and more student diversity in learning needs and cultural backgrounds, less time was available for informal learning possibilities. Teachers spent more time on classroom management and less time was available for sharing with colleagues or experimenting with new teaching strategies (Lohman, 2000). In addition, less overall non-teaching time was available to teachers as committee work or other administrative duties were added to contractual assignments (Lohman, 2000, 2006; Wei et al., 2009). Scribner (1999) discussed how time constraints and the lack of choice about resource use led to the increased use of formal professional development measures while informal experiences like sharing or reading declined. The lack of time also limited the abilities of secondary teachers to share resources and materials (Lohman, 2000, 2006). In this age of global comparisons, American teachers spend 80% of their work-related time engaged in classroom instruction with students while teachers in other nations spend 60% of their time in such activities (Wei et al., 2009).

Money.

There are many financial costs directly associated with formal professional development such as workshop or conference attendance. The conference usually requires a registration fee or membership charge. Transportation, hotel, and dining costs are associated with distant sites (Schibeci & Hickey, 2004). Salaries for substitute teachers may be required for off-site sessions or to free teacher time for peer observations (Lohman, 2000). Childcare costs may also be an indirect detriment to participation. If the fees and costs are not covered by the school district, attendance may put undue strain on personal or family finances (Schibeci & Hickey, 2004; Wan & Lam, 2010; Wei et al., 2009). In fact, the majority teachers in the United States must pay for their own professional development costs including travel, registration costs, or tuition, while the same is not true for educational counterparts in other countries (Wei et al., 2009).

Monetary remuneration may supply some extrinsic motivation for teachers for formal or informal learning. Compensation that comes from stipends or scholarships may offer immediate benefits, especially to new teachers (Higgins, 2006; Scribner, 1999; Schibeci & Hickey, 2004). Reduced entry fees for returning participants may also be a direct benefit (Schibeci & Hickey, 2004). Participation in certain trainings or formal courses may translate into increased salaries or job promotions for the long-term (Schibeci & Hickey, 2004; Wan& Lam, 2010). However, experienced teachers may question whether the small amounts of financial inputs are worth their time and energy (Knight, 2000; Kwakman, 2003; Lohman, 2000, 2006; Scribner, 1999).

Other rewards.

Besides time use and monetary incentives, teachers may also consider other benefits that accompany professional development participation. Material incentives such as free books or curricular packages may act as an impetus for participation (Schibeci & Hickey, 2004). Participation in professional development activities may result in various skills and knowledge being added to résumés or curriculum vitae (Schibeci & Hickey, 2004). Other career-related benefits include leadership roles or job promotions (Lieb, 1991; Lohman, 2000, 2003; Wan & Lam, 2010). Participation in professional development may include the advantage of achieving college or university credits (Jeanpierre, Oberhauser, & Freeman, 2005; Schibeci & Hickey, 2004; Wan & Lam, 2010) or contribute to licensure requirements (Guskey, 2002; Lieb, 1991; Scribner, 1999). The opportunity to travel or encounter variety in work situations may offer personal enjoyment as a simple reward (Kwakman, 2003; Schibeci & Hickey, 2004). Even a basic recognition by administrators may be a reward for professional development efforts, but the lack of such recognition often leads to reduced participation in non-teaching activities like informal professional development (Lohman, 2000).

Proximity.

The distances that need to be traversed to engage in professional development are also considerations for teachers. Participation in formal professional development at off-site locations was affected by the distance, as well as the necessity for transportation (Lieb, 1991; Loucks-Horsley et al., 2010; Schibeci & Hickey, 2004). The closeness to colleagues' locations can affect the abilities to engage in knowledge and resource sharing (Lohman, 2000; Scribner, 1999). For high school teachers, the distance from the departmental office was noted to affect informal professional development communications (Lohman, 2000). Access to computer technologies in convenient locations for individual research opportunities or electronic communications can be difficult to accomplish, especially as classroom space is scheduled to full capacity use (Lohman, 2000, 2006). Similarly, the use of the school library or community resources depended upon the location of the teachers' classrooms (Lohman, 2000). Due to the proximity of these resources and the amount of time available, the abilities of teachers to search for new informational sources was severely limited (Lohman, 2000). With a little creative effort, reconfigured spaces could provide better opportunities for communication and collaboration to resolve some of the proximity issues (Scribner, 1999).

Relationships .

Besides the motivation to improve student-teacher interactions, relationships with others are factors that may directly or indirectly affect teacher participation in professional development. Colleagues may provide recommendations for professional development, although, at times, this may be construed as a pressure to participate (Higgins, 2006; Schibeci & Hickey, 2004). Collegial support is a very influential motivator for professional development participation (Borko & Putnam, 1996; Hargreaves, 2004; Hoekstra & Korthagen, 2011; Kwakman, 2003; Meister, 2010; Schibeci & Hickey, 2004; Wan & Lam, 2010). Networking with teachers from other districts in off-site sessions provided the added benefits of new informational sources (Higgins, 2006; Lohman, 2000).

However, relationships (or the lack of relationships) with educational peers can also create detrimental effects. Teacher isolation actually perpetuates a lack of collaboration and the pursuit of solitary formal professional development (Scribner, 1999). Interpersonal conflicts and overwhelming negative attitudes about school issues may deter engaged participation (Knight, 2000; Kwakman, 2003; Lucas, 1996; Scribner, 1999). Conflicts with colleagues may also hamper professional development participation (Knight, 2000; Kwakman, 2003; Lohman, 2000, 2006; Scribner, 1999; Terehoff, 2002). In addition, the combined actions of teachers may be able to block reform efforts if clear goals are not established (Guskey, 2003).

Relationships with leaders and perceptions of power are issues that influence teachers' decisions to participate in professional development. Due to an internal sense of obligation to help the school system, teachers may pursue a productive working relationship with administrators in professional development situations (Kwakman, 2003; Lohman, 2006; Meijer, Korthagen, & Vasalos, 2009; Scribner, 1999; Wan & Lam, 2010). Professional development that is related to district goals is more likely to encourage teacher buy-in and participation (Wan and Lam, 2010). The leaderships' ability to provide or limit access to resources determines how much commitment teachers will add to professional development relationships (Lohman, 2000; Loucks-Horsley et al., 2010; Lucas, 1996; Scribner, 1999). Bransford et al. (1999) explained that the majority of teachers had no voice in the topic or method of their learning. The lack of teacher decision-making powers regarding professional development choices contributes to conflicts with administrators who do make the decisions (Borko & Putnam, 1996; Knight, 2000; Lohman, 2000; Meister, 2010; Schibeci & Hickey, 2004; Scribner, 1999). When compelled professional development is also considered ineffective, relationships with administrators continue to suffer (Knight, 2000; Meister, 2010; Schibeci & Hickey, 2004; Scribner, 1999; Wan & Lam, 2010). Although the school leadership may encourage informal experimentation and collaborative sharing, negative perceptions of managerial support will discourage such learning opportunities (Kwakman, 2003; Scribner, 1999).

Personal relationships with spousal partners and family members need to be balanced with work-related activities. Although family members may be beneficial supporters of personal growth, participation in formal professional development may have a negative impact if time away from family members is required (Loucks-Horsley et al., 2010; Schibeci & Hickey, 2004; Scribner, 1999; Wan and Lam, 2010). Home schedules and responsibilities may be disrupted or childcare difficulties may arise (Lieb, 1991; Schibeci & Hickey, 2004; Wan & Lam, 2010). A lack of familial support will definitely impact the professional development participation of teachers with families.

Just as Barry Commoner (1976) suggested in *The Poverty of Power* that economic and environmental issues are linked to decisions about how humans choose to use their energy sources, a similar analogy could be connected to school systems. The multiple levels of human relationships involved in school systems are often dependent upon the monetary and material resources. How a school decides to allocate material and human resources, as well as the control of decision-making processes, affects the school's (or district's) environmental climate which, in turn, affects how individual teachers choose to apply their time, money, and energy. A lack of decision-making power in the processes controlling classroom autonomy and professional development opportunities may affect the participation in "non-essential" non-teaching activities.

Personal intrinsic factors.

Personal intrinsic factors that affect professional development participation may be difficult to separate from other factors. Lohman (2000) suggested that environmental inhibitors should be addressed before personal factors are considered as professional development motivators. However, the personal and professional lives of teachers are so intertwined that their effects on decisions and actions would be impossible to separate and categorize (Day & Leitch, 2001; Higgins, 2006; Kwakman, 2003; Schibeci &

Hickey, 2004; Scribner, 1999; Wan & Lam, 2010). As teachers, the first and foremost reason to pursue professional development is a desire to help students (Guskey, 2002; Scribner, 1999). Lohman (2003, 2006) described the positive influence of teachers' initiative to start and continue informal professional development processes in order to find better ways to help students. A major personal influence of professional development participation is the overwhelming desire to learn (Guskey, 2002; Hoekstra & Korthagen, 2011; Lieb, 1991). The learning may include increasing the depth and breadth of content knowledge (Lohman, 2006; Scribner, 1999). Pedagogical strategies for improved student learning and engagement are other incentives for the pursuit of teacher learning (Scribner, 1999). Lohman (2006) found that the nurturing and outgoing personalities of teachers were factors that supported the use of informal professional development learning in their work environments. Classroom management techniques to support the increased class sizes and student diversity also influenced personal desires for learning in order to help students or, in times of classroom difficulties, to promote a sense of survival on a self-journey (Knight, 2000; Kwakman, 2003; Lohman, 2000, 2006; Meister, 2010; Schibeci & Hickey, 2004; Scribner, 1999). Teachers and other adult learners may have an intrinsic motivation for life-long learning encouraged by other life activities such as hobbies, volunteering, or secondary jobs (Meister, 2010; Schibeci & Hickey, 2004). As teachers' life experiences continue to overlap with professional work, the teachers may seek professional development opportunities such as technology integration that may offer benefits in multiple contexts (Higgins, 2006; Scribner, 1999).

Teacher beliefs may positively or negatively impact professional development participation. Teacher knowledge and beliefs "influences their sense-making and informs the choice they make in everyday life" (Loucks-Horsley, 2010, p. 52) including professional development engagement. Teachers' sense of self-efficacy (the belief about one's effectiveness) and their personal levels of confidence in their abilities to effect change in their students determined the choice to participate in professional development (Borko & Putnam, 1996; Hoekstra & Korthagen, 2011; Korthagen, 2004; Lohman, 2003, 2006; Meister, 2010). A positive sense of self-efficacy encouraged professional development participation (Hoekstra & Korthagen, 2011; Kwakman, 2003; Lohman, 2003, 2006; Meijer et al., 2009; Meister, 2010; Schibeci & Hickey, 2004). On the other hand, negative perceptions of self-efficacy would limit professional development engagement (Borko & Putnam, 1996; Knight, 2000).

Teacher beliefs about the dilemmas in modern society also affect their sense of self-efficacy. As school violence episodes increase, teachers worry about their abilities to keep students safe (Scribner, 1999). Social issues such as gang involvement, drug use, teenage pregnancy, lack of parental involvement, and a general lack of confidence in public school systems are external factors that affect teacher decisions in the classroom as well as their needs or desires for continued learning (Knight, 2000; Scribner, 1999).

Teacher frustration with the social issues also carries over into their working conditions. As teachers' workloads increase with larger class sizes, changing student populations, and mandated programs, teacher stress also increases (Knight, 2000; Kwakman, 2003; Lohman, 2000, 2003, 2006; Schibeci & Hickey, 2004; Scribner, 1999).

Stress is further complicated by the lack of leisurely activities and family time (Loucks-Horsley, 2010; Schibeci & Hickey, 2004; Scribner, 1999; Wan & Lam, 2010). Higher stress levels are translated into more teacher isolation, less teacher collaboration, and less individual learning motivation (Kwakman, 2003). Frustration, anxiety, worry, and exhaustion, both mental and physical, can be overwhelming personal factors for teachers that prevent their professional development participation (Fullan & Stiegelbauer, 1991; Hargreaves, 2004; Knight, 2000; Lohman, 2003; Scribner, 1999).

Negative beliefs about impractical and ineffective professional development, especially formal sessions with administratively compelled attendance, directly detracted from the engaged participation of teachers (Knight, 2000; Kwakman, 2003; Meister, 2010; Scribner, 1999; Wan & Lam, 2010). Mandated professional development led to frustration with unwilling group members, conflicts with administrators and community members, and general resentment over the lack of teacher autonomy and decision-making powers (Hargreaves, 2004; Knight, 2000; Lohman, 2003; Lucas, 1996; Scribner, 1999). Teachers were not necessarily resistant to all programs, but deplored the lack of coherence and sense of direction that typically comes with mandated changes, especially those that were at odds with their own teaching purposes (Fullan & Stiegelbauer, 1991; Garet et al., 2001; Hargreaves, 2004; Musanti & Pence, 2010).

As teachers perceived that their autonomy over classroom decisions and professional development participation was threatened, negative feelings escalated (Hargreaves, 2004; Knight, 2000; Lohman, 2003; Scribner, 1999). Day and Leitch (2001) discussed the intense feelings that teachers displayed when their personal self was compromised. Hargreaves (2004) found that teachers were very frustrated by not being able to direct their own goals, but enthusiasm was apparent when self-initiated activities were encouraged. However, teachers felt angry at having to justify how they were spending their non-teaching time to administrators or community members (Lohman, 2003). Negative perceptions were often compounded by pressures to follow district policies and procedures, such as guidelines for technology integration (Higgins, 2006; Lohman, 2003; Scribner, 1999).

Fullan and Hargreaves (1996) explained that the teaching profession is committed to academics as well as caring for others. Teachers' choices and decisions are ultimately motivated by their own purposes (Ball, 1996; Fullan & Hargreaves, 1996; Loucks-Horsley, 2010; Musanti & Pence, 2010). Even when environmental factors are inhibitory toward formal or informal professional development opportunities, teachers relied on their personal characteristics and wherewithal to continue their own growth (Higgins, 2006; Kwakman, 2003; Lohman, 2003). Therefore, in order to ensure engaged participation, the professional expertise and feelings of teachers need to be recognized and valued (Easton, 2004).

Science Teacher Professional Development

The components of high quality professional development apply to science teaching just as they do for other content areas. Loucks-Horsley et al. (2010) discussed that "effective professional development designs are grounded solidly in research knowledge and on the particular needs, contexts, and circumstances of the participants" (p. 52). Non-traditional "reform" types of professional development other than workshops are also recommended for science teachers (Desimone, Porter, Garet, Yoon, & Birman, 2002; Hanuscin, van Garderen, Menon, Davis, Lee, & Smith, 2011; Van Driel, Beijaard, & Verloop, 2001). The professional lives of science teachers and the continual changes in scientific knowledge necessitate life-long learning activities, especially while encouraging scientific literacy for students (Abell & Lee, 2008; Lee & Luft, 2008; National Research Council, 1996; Van Driel et al., 2001). Science teacher professional development should be goal-oriented (Higgins, 2006; Lee & Luft, 2008; Loucks-Horsley et al., 2010; National Research Council, 1996) and tied to other aspects of reform (Desimone et al., 2002; Garet et al., 2001; Loucks-Horsley et al., 2010; National Research Council, 1996; Penuel, Fishman, Gallagher, Korbak, & Lopez-Prado, 2009). Constructivist designs that are based upon teachers' needs (Counsell, 2011; Loucks-Horsley et al., 2010; Park Rogers et al., 2010) and applicable to classroom situations (Blank & de las Alas, 2009; Jeanpierre, Oberhauser, & Freeman, 2005; Lee & Luft, 2008; Loucks-Horsley et al., 2010; National Research Council, 1996; Yerrick, Parke, & Nugent, 1997) are essential elements of high quality professional development for science teachers. Hutchins, Arbaugh, Abell, Marra, & Lee (2008) suggested that a professional development session for science teachers should have a narrow focus by grade level or discipline content area to ensure that the differentiated teacher needs are being met. Science teacher professional development should be job-embedded (Abell & Lee, 2008; Hanuscin et al., 2011; Higgins, 2006; Loucks-Horsley et al., 2010; National Research Council, 1996; Yager, 2005) and sustained over time as well as intensive in contact hours (Banilower et al., 2010; Desimone, et al., 2002; Garet et al., 2001;

Klentschy, 2005; Loucks-Horsley et al., 2010; Supovitz & Turner, 2000; Van Driel et al., 2001; Yager, 2005). Finally, science teacher professional development should involve collegial relationships (Desimone et al., 2002; Garet et al., 2001; Hutchins et al., 2008; Loucks-Horsley et al., 2010; Van Driel et al., 2001; Yager, 2005; Yerrick et al., 1997).

In conjunction with the components of high quality professional development, certain additional elements apply specifically to science teacher learning. Loucks-Horsley et al. (2010) explained that "knowledge of content, although critical, is not enough, nor is knowledge of general pedagogy. There is something more to professional development for science and mathematics teachers than generic professional development opportunities are able to offer" (p. 15). Science teachers do need to understand science concepts at a depth and breadth appropriate to their grade level and science discipline (Desimone et al., 2002; Garet et al., 2001; Jeanpierre et al., 2005; Park Rogers et al., 2010; Van Driel et al., 2001; Woolhouse & Cochrane, 2009). In addition, science teachers need to have knowledge of how diverse students with varying abilities and experiences learn science based on their prior knowledge or the anticipated misconceptions that students may carry (Banilower et al., 2010; Lee & Luft, 2008; Loucks-Horsley et al., 2010; National Research Council, 1996, 2011; Yager, 2005). Furthermore, science teachers require pedagogical content knowledge to understand which science teaching practices would most benefit the student development of science concepts and skills (Banilower et al., 2010; Blank & de la Alas, 2009; Lee & Luft, 2008; Park Rogers et al., 2010; Woolhouse & Cochrane, 2009; Yager, 2005; Yerrick et al., 1997). Professional development specifically designed for science teachers would cater to the appropriate content knowledge and science teaching practices that are necessary for a science teacher's work with students.

Science has particular strategies that teachers need to experience as well as understand. Science teachers should participate in active learning with materials (Desimone et al., 2002; Garet et al., 2001; Hanuscin et al., 2011; Jeanpierre et al., 2005; National Research Council, 1996; Park Rogers et al., 2010; Yerrick et al., 1997) while encountering learning outcomes similar to those expected of students and contextually embedded with their science teaching (Banilower et al., 2010; Desimone et al., 2002; Hanuscin et al., 2011; Jeanpierre et al., 2005; Loucks-Horsley et al., 2010; National Research Council, 1996; Woolhouse & Cochrane, 2009). For example, teachers should be immersed in the nature of science, inquiry learning, the conceptual modeling approach, or the 5Es (engage, explore, explain, elaborate, evaluate) themselves before conveying such strategies to students. However, the engagement events need to include conceptual explanations and more than "whiz bang, cool science activities" (Robertson, 2010, p. 63) to ensure that hands-on sessions are also mind-on (Wiggins & McTighe, 2005). With class demonstrations and experiments, science teachers also need to be effective classroom managers in order for students to safely navigate laboratory environments (National Research Council, 1996).

Because of the unique nature of the National Science Education Standards developed in 1996 and the recently released Framework for K-12 Science Education, science teachers will need specialized professional development to align, integrate, and implement these facets into their classroom curriculum (Desimone et al., 2002; Hutchins et al., 2008; Lee & Luft, 2008; Loucks-Horsley et al., 2010; National Research Council, 1996; National Research Council, 2011; Penuel et al., 2009; Yerrick et al., 1997). The Framework has three main dimensions: the skills involved in scientific and engineering practices, the cross-cutting concepts weaving through each discipline, and the disciplinary core ideas (National Research Council, 2011). To guarantee that the vision of the Framework is realized, professional development opportunities that encourage teachers to understand and apply these dimensions in their own classrooms will be vital. Additionally, professional development should also ensure that learning is supporting the district policies and procedures as well as the national Framework (Blank & de la Alas, 2009; Hutchins et al., 2008; Yerrick et al., 1997). Therefore, because of the "strong relationship between high quality professional development and the kinds of teaching practices that are advocated by science reformers" (Supovitz & Turner, 2000, p. 976) districts should be encouraged to provide effective opportunities for their science teachers.

Science teachers are the community connections to science and require knowledge relevant to global, societal issues (National Research Council, 1996). Professional development should ensure that science teachers have knowledge of and access to resources to supplement their knowledge for such purpose (Klentschy, 2005; Loucks-Horsley et al., 2010; National Research Council, 1996; Park Rogers et al., 2010). Science teacher professional development should provide partnerships with science organizations and higher educational institutions, especially with opportunities to conduct experimental research in a science discipline (Adams et al., 2008; Counsell, 2011;

National Research Council, 1996, 2011). Counsell (2011) discussed how science teachers must first learn to experiment themselves before they can become "experimentors" for young science students. And even though laboratories may be great places to learn science, "learning to teach science needs to take place through interactions with practitioners in places where students are learning sciences, such as classrooms and schools" (National Research Council, 1996, p. 58).

Loucks-Horsley et al. (2010) listed a variety of high quality professional development strategies to guide learning situations for science and mathematics teachers. These strategies were divided into four groupings: "(1) immersion in content, standards, and research, (2) examining teaching and learning, (3) aligning and implementing curriculum, and (4) professional development structures" (p. 166). The first category includes strategies such as curriculum topic study (CTS), immersion into scientific inquiry, and science related content courses. The second category contains strategies such as lesson study, action research, examining student work, demonstration lessons, and case discussions of classroom situations, as well as peer coaching and mentoring of new teachers. Approaches in the third category incorporate the selection of instructional materials and the implementation of new curriculum. Finally, the fourth cluster utilizes study groups, more formal professional development sessions (workshops, institutes, and seminars), networking with other professionals in a community of practice, and online professional development such as webinars, podcasts, or chat rooms. These strategies are high quality professional development activities that have specific content-related topics necessary for teachers of scientific literacy.

Characteristics of Science Teachers

The majority of science teachers do participate in professional development. According to the National Science Board (2012) in the Science and Engineering Indicator 2012 report, science teachers participated in content-focused professional development at a rate of 77% and in professional development related to the use of computers at a rate of 69%. Other professional development topics (discipline or classroom management, teaching students with disabilities, or teaching students with limited English proficiency) garnered much less than 50% participation from science teachers (National Science Board, 2012).

Although teachers in general may share some similar personality and behavioral characteristics as well as pedagogical interests, some studies have indicated that science teachers may share some common traits that differ from teachers of other content areas. The Logical-Mathematical Intelligence introduced by Gardner (2004) suggested that scientists prefer practical and applied learning rather than just seeking the existence of ideas. Holland's (1973) RIASEC codes included Realistic, Investigative, Artistic, Social, Enterprising, and Conventional with the Investigative category more relevant to scientific careers. Main and Hounshell (1973) used Cattell's 16 Personality Factor Questionnaire to describe science teachers as being "more reserved, calm and mature than teachers in other disciplines" (p. 71), as well as being more serious and self-sufficient. In general, teachers with more than five years of experience were more likely to be less adventurous than their younger, more aggressive counterparts (Main & Hounshell, 1973). In 2000, Sechler's dissertation found that science teachers who are risk-takers and flexible planners are more likely to implement information and skills from professional development into their classroom situations. In addition, Rushton, Morgan, and Richard (2007) found that teachers who are Extraverted-Intuitive-Feeling-Perceiving (ENFP) and Extraverted-Intuitive-Thinking-Perceiving (ENTP) are more likely to be educational reformers and agents of change because they are willing to take risks and adapt to changes. However, according to Tieger and Barron-Tieger (1995), a career of high school science teaching is more likely to suit the Extraverted-Intuitive-Thinking-Judging (ENTJ) type profile on the Myers-Briggs Type Indicator, while Introverted-Intuitive-Thinking-Judging (INTJ) types would be university teachers and mathematicians. Teachers who possess the Intuitive Thinker (NT) temperament are more likely to be curious, constantly seeking new knowledge, and trying to capture holistic views of any problem. At the same time, NTs may also be skeptics who like to challenge authority and are unconcerned with the emotions of others. Similarly the cognitive style studied by Billington, Baron-Cohen, and Wheelwright (2007) found that students majoring in physical sciences were more likely to be highly systemizing (concerned with analyzing the rules of a system) and less likely to be empathizing (concerned with the emotional state of others). If many science teachers share commonalities that are different from characteristics of teachers in other content areas, then professional development opportunities should recognize these differences and make accommodations to suit the needs of the science teachers, as well as encourage collegial relationships with teachers of various personality profiles who may model risk-taking and classroom experimental behaviors.

Summary

In this chapter, the literature review described the findings of research related to teacher professional development. The main themes of the literature review included the following section headings: The Definition of Professional Development, The Purposes of Professional Development, The Components of Effective Professional Development, Adult Learning, Professional Development Participation, Factors Affecting Participation: Time, Money, Other rewards, Proximity, Relationships, and Personal intrinsic factors; Science Teacher Professional Development, and Characteristics of Science Teachers.

The next chapters will describe the mixed methods research design, the results from the quantitative survey and qualitative interview data collections, and the analysis of those results to make recommendations for the future use of this study.

Chapter 3. Methodology

Introduction

Though many research efforts have collected information about the factors affecting teacher participation in professional development, many of these efforts involved low numbers of participants and only a few were related to science teachers. These studies have occurred in areas such as the Netherlands, China, and states such as Texas and California, but a similar study has not been performed in Minnesota. Minnesota (along with many other states) only achieved a ranking of four out of eight possible indicators for professional development access (Wei et al., 2010), making such a discrepancy logical to explore. In addition, Minnesota science teachers comprised a new and different population from those previously studied. Thus, there was a need to understand the professional development activities in which Minnesota science teachers have engaged and the factors that affected their participation in those professional development activities.

Research Questions

In the first phase, quantitative research questions addressed the descriptions of the types of professional development in which experienced, highly qualified secondary science teachers participate and the supporting and inhibiting factors that influence their participation. Additional, personalized descriptions of professional development experiences were collected through qualitative interviews with willing survey respondents at various levels of teaching experience.

1. In what types of professional development do experienced, highly qualified, secondary science teachers in Minnesota engage?

2. What factors influence their decision to participate in any type of professional development activities?
    a. What intrinsic factors promote participation?
    b. What intrinsic factors inhibit participation?
    c. What extrinsic factors promote participation?
    d. What extrinsic factors inhibit participation?
3. How do experienced, secondary science teachers describe the factors that affect their professional development experiences?

Research Methodology

A two-stage mixed methods approach was utilized for this research study. This mixed methods approach was similar to the methods used by previous researchers on professional development (Higgins, 2006; Lohman, 2000, 2003, 2006; Wan & Lam, 2010). The quantitative survey portion and the qualitative interview portion were designed in a concurrent manner, but performed sequentially with qualitative interview participants selected from voluntary responses on the survey. Initially, a quantitative study of experienced, secondary science teachers in Minnesota was performed using a cross-sectional survey design. The quantitative data collection was in the form of self-administered questionnaires using online Qualtrics software. Finally, individual teachers who provided contact information for further semi-structured, qualitative interviews were selected according to their survey responses regarding years of teaching experience. Individual teacher interviews were performed to add more depth and personal stories to the survey results, as suggested by Eisner (1991) because "we need to listen to what people have to say about their activities, their feelings, and their lives" (p. 183).

Participants

The participant sample was randomly selected from the pool of experienced, highly qualified secondary school science teachers currently teaching in Minnesota. The population of experienced, highly qualified secondary school science teachers would include teachers who had been teaching any discipline of science in grades five through twelve for five or more years (Hoekstra et al., 2009, p. 665). The Minnesota Department of Education (2009) reported that 14,897 teachers were licensed to teach in various disciplines of science (chemistry, earth and space science, life science, physical science, general science, junior high science, and physics). However, the researcher was informed that neither a database nor list of currently employed science teachers existed at the Minnesota Department of Education (J. Olson, personal communication, August 14, 2012) or through the Minnesota Science Teachers Association (E. Hessler, personal communication, August 30, 2012). As an alternative, two Excel files holding the names of highly qualified teachers in Minnesota for 2010–2011 were arranged alphabetically by A–K and L–Z and were downloaded from the Highly Qualified Teacher Requirements page of the Minnesota Department of Education website. These files contained all highly qualified teachers in Minnesota for all grade levels and all content areas. In order to create a list of only highly qualified science teachers, the two Excel files were combined and the entire list was filtered according to the Staff Automated Reporting (STAR) codes that designated science teachers. The Staff Automated Reporting (STAR) codes were downloaded as an Excel file from the STAR Web Edit System web page (Minnesota Department of Education, 2012a) and the 19 STAR codes designating science teachers, ranging from 130010 to 130502, were used to select only science teachers in the Excel file. Teachers with STAR codes other than those used to designate science teachers were removed from the Excel file. Since the highly qualified teacher data listed individual science teachers' names multiple times for each course taught, duplicate names for teachers with multiple teaching assignments were deleted. Teachers for grades kindergarten through fourth grade were not considered secondary science teachers according to the research questions and their names were also removed from the file. Eventually, the entire highly qualified teacher file was filtered down to a total list of 3389 highly qualified secondary science teachers from Minnesota.

When the size of the population was estimated, the proper sample size to use was researched and determined. Bartlett, Kotrlik, and Higgins (2001) suggested that a minimum returned sample for a population of 4000 was 119 for continuous data. The population of secondary science teachers was determined to be close to 3400, so a returned sample of 100 surveys was a reasonable expectation and suggested by Gall et al. (2007) as the minimum number of participants for survey method. However, Sauermann and Roach (2013) indicated that a typical response rate for detailed online surveys was between 10 – 25% and Mertler (2003) had a response rate of 11% with a similar online survey of 100 teachers. Using the hopeful estimate of a 25% response rate, the amount of distributed surveys would have been 400 to have 100 surveys returned. Using the pessimistic estimate of 10%, 1000 surveys would have to be distributed to receive 100 surveys back. The final number of surveys selected for distribution was 600, between the two estimates.

The 3389 science teachers' names were then uploaded to Qualtrics. Using the "more random" option available on the Qualtrics software random sample generator, the appropriate algorithm was applied to select a truly random sample and create a panel of science teachers. Then, the newly selected random sample of 600 highly qualified science teachers was again downloaded to an Excel file. Individual email addresses for the random sample of 600 highly qualified science teachers were collected from district and school website directory information, as well as from the School District Contact list which was also downloaded from the Minnesota Department of Education (2012b) website. If a teacher was not found in the school district directory listed in the highly qualified teacher data, the teacher's current assignment was located through the Teacher License Lookup at the Minnesota Department of Education website using the teacher's file folder number listed on the highly qualified list. Eventually, 564 science teacher email addresses were located with the final 36 names from the random sample unable to be connected with a current teaching assignment in Minnesota.

Research Design

Quantitative instrument development.

Qualtrics was selected as the survey development software for several reasons. The researcher was already familiar with the software due to use in coursework and a student account was already established with no additional fees incurred. Qualtrics offered a password protected account and the researcher was able to control individual permissions for access to the data. In addition, Qualtrics' security included Transport Layer Security (TLS) and encryption (HTTPS). The data is stored in audited data centers which are SAS 70 certified (J. Rabino, personal communication, October 12, 2012).

The survey questions were designed using formatting principles to ensure better survey responses. Dillman (2000) suggested using a 12-point font with clearly focused directions and questions. A simple design was used and each questions was presented on a separate page for easier reading. Demographic questions were not used for the initial questions in order to have more interesting topics to encourage participation (Dillman, 2000). Questions that asked participants to check all that apply were limited to demographic questions relating to academic degrees, grade levels taught, and science disciplines taught. No drop-down boxes were used, but at least two questions asked participants to rank levels of supporting or inhibiting factors. Skip logic was used for some secondary questions relating to sub-factors in order to reduce the amount of questions each respondent needed to complete. Following the suggested design principles and procedures of Dillman (2000) were helpful in limiting measurement errors related to unclear questions or formatting confusions.

Most of the survey questions were constructed from the findings of previous research from the literature review. Some questions also combined information from full or partial questions based on the previously validated professional development portions of the Organisation for the Economic Co-operation and Development (2008) Teaching and Learning International Survey (TALIS), the School and Staffing Survey (SASS) from the U. S. Department of Education (2008), and the Horizon Research and Westat (2000)

National Science and Mathematics Survey. In particular, question 4 listed some survey choices that are found in both the U. S. Department of Education's (2008) and Organisation for the Economic Co-operation and Development (2008) surveys. Question 6 included some options adapted from surveys by Horizon Research and Westat (2000) and Organisation for the Economic Co-operation and Development (2008). Question 8 contained options from Lohman (2006), the U. S. Department of Education (2008) and the Organisation for the Economic Co-operation and Development (2008). Questions 29 and 32 were adapted from the Horizon Research and Westat (2000) survey.

Validity and reliability tests.

Validity ensures that the instrument is appropriately measuring the required information (Gall et al., 2007). The established surveys from the Organisation for the Economic Co-operation and Development (2008), U. S. Department of Education (2008), and the Horizon Inc. and Westat (2000) used validation strategies that involved having the surveys created and reviewed by experts, pilot-tested with appropriate sample populations, and revised to avoid ambiguity in question wording. Any newly created or combined questions followed Dillman’s (2000) suggestions for distinct survey directions and clearly stated survey questions. Then the entire survey, including the newly constructed questions, was briefly pilot tested by a convenience sample of a similar population of 11 science teachers who were members of the National Science Teacher Association email listservs. An additional validation occurred through a face-to-face “talk-through” with a local social studies teacher answering questions based on that content area. The entire survey was also reviewed by dissertation committee members with expertise in the area of surveys and quantitative data collection. The wording and format of some survey questions were changed for better clarification and the updated survey was resubmitted to the Institutional Review Board (IRB) as a change in protocol.

Quantitative data collection.

The dissemination of the survey followed a Tailored Design Method (TDM) suggested by Dillman (2000). The first step was to send a pre-notice email message at the end of November, 2012 before the actual survey was sent. The pre-notices were not individually personalized because they were sent from the Qualtrics system in order to be able to track responses and nonresponses. A second email message contained an invitation to participate with an individualized link to the online Qualtrics survey for participant convenience. The random sample of 600 highly qualified science teachers were each assigned an individualized recipient identification code for the researcher to track survey responses and non-responses, as well as allow survey respondents to pause their survey responses and return to finish at a later time with their previous entries saved. The online Qualtrics survey consisted of a welcome message with the consent form, brief directions to complete the survey, and the actual survey questions. Toward the end of the survey, participants were asked if they would be willing to participate in follow-up interviews for further descriptions of their professional development experiences and, if so, to provide their preferred form of contact information (email address, work telephone number, or home telephone number). When the survey was completed, a thank you message for respondents appeared on the screen and an additional thank you email was sent. The researcher was able to view and export the completed survey information in various report and data formats. About 10 days after the initial survey was distributed, an email reminder with the survey link was sent to non-respondents and to people who may have started the survey, but not finished because the Qualtrics survey saved their previous entries. After a few weeks and following the winter holiday break, an additional link to the online survey was included in a second email reminder, with a final reminder occurring about 3 weeks later.

Qualitative instrument development.

Questions for the interview (See Appendix B.), combined protocols from previous studies about teacher professional development with survey questions developed by the researcher to conduct science teacher interviews during qualitative research course (Lohman, 2003; Scribner, 1999). Interview questions 12 and 13, along with their related sub-questions were adapted from Lohman (2003). Interview questions 14 and 15 also came from Lohman (2003). Adaptations from Scribner (1999) were used for interview questions 5 and 6. The remaining interview questions were designed by the researcher.

Validity and reliability.

The interview protocol was based on previously utilized procedures in Scribner (1999) and Lohman (2003). The adapted questions used were from previously validated interview questions by Lohman (2003) and Scribner (1999), as well as the researcher's own questions previously to interview a local science teacher regarding personal professional development experiences. The interview questions were reviewed by a dissertation committee member with expertise in qualitative interview processes.

In order to show the reliability of the information from the survey, the specific research protocols were noted to ensure that another researcher could replicate the study in the same manner (Gall et al., 2007).

A critical step to ensuring the validity of qualitative data is for the researcher to bracket and set aside any possible assumptions that may interfere with the data interpretation. A personal identity memo written by the researcher regarding personal teacher experiences and professional development opportunities encouraged self-awareness of possible preconceptions that would need to be bracketed, as suggested by Maxwell (2005). Gall et al. (2007) also listed Maxwell's (2005) strategies to ensure validity for qualitative research which were followed during this research study. The first step was to meet the user's needs by ascertaining the usefulness of the research, making the process participatory, protecting the chain of evidence, and using truthful reporting (Gall et al., 2007). Other steps involved data triangulation, checks for representativeness, and coding checks. The researcher has experience transcribing data from focus groups and using open coding strategies for the transcription analysis, as well as for journal entries and reflective statements related to a specific program evaluation. Additionally, the researcher continued to perform personal reflections about the process. Multiple steps were taken to ensure the validity and reliability of the study.

Qualitative interview data collection.

Qualitative interviews were conducted to obtain more descriptive information about the personal professional development experiences of science teachers who volunteered their contact information at the end of the quantitative survey. Teachers with varying demographic information (school size, science disciplines taught, and age of students taught) were interviewed based on their years of teaching experience. The five science teachers participating in the interview process were designated by pseudonyms based on the military alphabet (Alfa, Bravo, Charlie, Delta, and Echo) to protect the confidentiality of their identities and their interview responses.

The qualitative interview phase followed a semi-structured interview process (Gall et al., 2007) and the suggestions listed by Trochim (2006) for successful interview procedures. The researcher personally performed the interviews in a location and time that was convenient for the interviewee, such as the local school site. The semi-structured interviews lasted approximately 30–45 minutes and began with introductions, as well as an explanation of the study purpose and confirmations of confidentiality . The researcher explained that the interviewee’s confidentiality would be protected and only the researcher would have access to any of the information provided. The researcher asked for permission to audio record the interviews on a Zoom H4N audio recorder freely available to students for checkout to elucidate the written notes taken during the interview. The researcher had each survey question (See Appendix B) printed on a separate sheet of paper for easier note-taking. Once the interviewee agreed to be recorded, the researcher asked the predetermined questions as the interviewee read a printed copy of the questions. In most cases, the researcher was able to provide a list of the questions for the interviewee to preview prior to the actual interview. At the conclusion of the interviewer, the researcher thanked the interviewees for their assistance.

Upon exit of the interview location, the researcher immediately recorded information and impressions about the recently completed interview process.

After each interview, the researcher read through the hand-written notes and reflected on the interviewee's responses. The researcher downloaded the wav audio files from the Zoom H4N onto a password-protected computer and transcribed each interview into a Word document table using Windows Media Player. Statements of meaning were gleaned from the interview responses and emerging themes were eventually highlighted in different colors. Statements in the same highlighted color were then combined to gather an overall "picture" of the science teachers' professional development experiences.

Data Analysis

Qualtrics reports combining all survey responses were downloaded to Microsoft Word files for analysis of the quantitative data. The frequency counts listed on one version of the report and the percentages listed in another version of the report were combined into a single report. The report listed the frequencies and percentages for the types of high quality professional development activities in which science teachers participated, as well as the formats for formal and informal opportunities. Frequency and percentage data for the supporting resource-related extrinsic factors that affect professional development participation were followed by the inhibiting resource-related extrinsic factors. Next, the supporting and inhibiting intrinsic factors were analyzed by frequencies. Then, the supporting extrinsic factors related to relationships with teacher colleagues, school administrators and family were also analyzed by frequencies, followed in a similar fashion by the inhibiting extrinsic factors relating to those same relationship categories. The frequencies for the demographic information were analyzed in Excel according to the following categories: science discipline, grade level taught, years of experience, and highest level of education. The demographics of regional participation for survey respondents are shown in Figure 1 in Chapter 4.

For the qualitative data analysis, careful procedures were followed to ensure continued validity of the qualitative data. When the interview data were collected from the individual teacher interviews, the recorded information was personally transcribed by the researcher. This transcription was performed soon after the interview while the information was still fresh in the mind of the researcher. The transcription information was then analyzed using Colaizzi's (1978) method as described in Creswell (2007). The process began with reading and rereading the transcribed responses, as well as referring to the notes taken during the interview. Next, noteworthy statements about professional development experiences, as well as supporting and inhibiting factors relating to participation were selected. Meanings were collected from those noteworthy statements and the statements were further examined for obscure meanings. Information was categorized into common themes using color codes with constant revisits to the original transcription text for validation. A model was created and some interviewees were contacted for validation.

Ethical Considerations

Several steps were taken to ensure the ethical treatment of the participants in order to protect the confidentiality of their identities and their responses. First, participants were given the opportunity to read a passive consent form on the online Qualtrics survey that provided the details of what information was to be collected, how it would be analyzed and used, who would have access to the information, how the information would be safeguarded, and how the information would be stored or disposed of when the research period was over. Since an individualized external link to the online survey was provided, concerns about employer access to the electronic responses were addressed (Dillman, 2000). Secondly, the survey construction considered the basic ethical principles of respect for persons, maximizing benefits and minimizing harm, and justice (Northwest Association for Biomedical Research, 2009). Because participation in the survey was voluntary, recipients of the survey link also received a link to opt out of receiving future reminder emails to complete the survey. The survey language also avoided the use of terms that may be construed as biased in any way and demographic questions related to race or ethnicity were removed from the survey after the pilot testing process, because such information was not related to the research questions. A third way in which ethical procedures were applied was the safe storage of the information in encrypted computer files on a password-protected private computer or locked cabinets for paperwork. Only the researcher had access to the Qualtrics survey data and Excel files containing the recipient identification codes. Finally, data files were stored or destroyed in the approved manner when the research period had been completed to avoid the possibility of the information being used inappropriately by other sources.

Similar steps were also performed for the qualitative interview portion of the study. The consent of the participants was obtained prior to the interviews, especially when audio recording the process. The interview protocol and questions considered the same ethical principles mentioned previously. The interview questions also avoided potentially biased questions and the interviewer attempted an ethical, impartial demeanor when phrasing the questions. Finally, only the researcher had access to the recorded audio files and notes from the interview. The data files including audio recordings of the interviews were disposed in the appropriate manner upon the successful completion of the research study.

Summary

This chapter described the mixed-methods approach utilized for this research study. An initial quantitative survey was followed by qualitative interviews with five of the survey respondents. Description of the selection process for research participants and the research design methods including instrument development were also discussed. The quantitative data were collected through an online Qualtrics survey of science teachers, requesting information about the formats and quality of their current professional development opportunities, as well as supporting and inhibiting factors that may affect their participation in professional development activities. The qualitative data were retrieved through personal, face to face semi-structured interviews with five of the science teacher survey respondents and was analyzed according to themes also present in the quantitative data relating to factors surrounding the availability of resources, external relationships, and personal intrinsic attributes.

Chapter 4. Results

Introduction

The purpose of this study was to describe the professional development experiences of experienced, highly qualified Minnesota science teachers for grades five through twelve and the intrinsic and extrinsic factors that affect their participation in professional development activities. A two-step mixed methods approach was utilized with an initial quantitative survey component which was subsequently triangulated with information collected through qualitative interviews of a small number of survey respondents. The researcher developed an online survey and interview questions using information gathered through a literature review of professional development research. Highly qualified science teachers for Minnesota students in grades five through twelve were invited to participate in the online survey and to also consider the possibility of participating in a follow-up interview. The remainder of this chapter will describe the analysis of the data resulting from the quantitative and qualitative methods.

Research Questions

The research study is based on the following research questions, with the first two mainly addressed by the quantitative survey portion and the third question addressed through the qualitative interview portion:

1. In what types of professional development do experienced, highly qualified, secondary science teachers in Minnesota engage?
2. What factors influence their decision to participate in any type of professional development activities?
    a. What intrinsic factors promote participation?

b. What intrinsic factors inhibit participation?

c. What extrinsic factors promote participation?

d. What extrinsic factors inhibit participation?

3. How do experienced, secondary science teachers describe the factors that affect their professional development experiences?

Data Analysis-Quantitative Survey

Of the 564 Qualtrics surveys that were successfully sent to teacher email addresses, 81 science teachers accessed the consent page and 69 science teachers actually answered portions of the first question. Fifty-nine surveys were fully completed for a response rate of 10%. Of the fully completed surveys, 52 were completed by respondents with five or more years of teaching experience to be considered experienced teachers as designated by the research questions. Since the consent form approved by the Institutional Review Board allowed participants to choose at any point whether to continue the survey, the number of experienced science teacher respondents varied by question between 52 with fully completed surveys and 62 with surveys in varying levels of completion. Only data from experienced teachers were included in the descriptions and tables discussing the results with the number of responses varying by question and data from teachers with less than four years of experience were completely excluded from the final statistics.

After three reminders had been sent requesting completion of the survey, a final report was created through Qualtrics. Response data from all completed surveys, as well as partially completed surveys, were consolidated into two Microsoft Word documents with one listing the frequency counts of participant answers and the second document listing the percentages of participant answers for each question. Data files of the responses were also exported to Excel and SPSS for other descriptive analyses. The data of the science teachers with less than five years of experience were placed into a separate Excel file for possible further analysis.

Participants-Quantitative Survey

Of the experienced science teacher survey respondents who completed the entire survey, 29 were male and 23 were female with varied levels of teaching experience. The largest percentage of respondents, (31%, n=16), had 5–10 years of teaching experience. Twenty-five percent (n = 13) had 11–15 years of experience. Thirteen percent (n = 7) had taught for 16–20 years. Eleven percent (n = 6) had taught for 21–25 years with the same statistics applying to the teachers with 26–30 years of teaching experience. Eight percent (n = 4) had taught for over 31 years.

According to the requirements for highly qualified teaching status, a licensed teacher for a core academic subject area must hold a major in that content area or pass the Minnesota licensure exam for that content area (Minnesota Department of Education, 2012d). The licensure data available from the Minnesota Department of Education (2011b) which was used to create the random sample of science teachers indicated that of the survey respondents, 79% (n = 41) held teaching licenses in life science, 17% (n = 9) held teaching licenses in earth science, 17% (n = 9) held teaching licenses in physical science (for chemistry and physics), 15% (n = 8) held licenses in chemistry, 11% (n = 6) held licenses in physics, 58% (n = 30) held licenses in general sciences for grades 5–8, grades 5–9, or junior high, and 6% (n = 3) hold licenses in elementary education. These licensure statistics include teachers who are licensed in multiple areas. Fourteen teachers (27%) held licenses in one area including elementary education, 27 teachers (52%) held licenses in two areas including elementary education, seven teachers (13%) held licenses in three science areas, and four teachers (8%) held licenses in four or more science areas.

Due to the specialization of individual science disciplines, academic majors in more than one area of science may be helpful for science teachers. Of the 52 experienced science teacher respondents who completed the survey, 33% (n = 17) completed a bachelor's degree in a single area, 40% (n = 21) completed bachelor's degrees in two areas, 23% (n = 12) reported bachelor's degrees in three areas, and four percent (n = 2) reported bachelor's degrees in more than three areas. A majority of the science teachers (n = 40) held a bachelor's degree in biology with over half of those science teachers (n = 27) completing degrees in other science disciplines or science education in addition to the biology component. Either as a single major or in combination with other majors, fifteen teachers (29%) completed bachelor's degrees in science education, fourteen teachers (27%) completed bachelor's degrees in chemistry, eleven teachers (21%) completed bachelor's degrees in earth and space science, eleven teachers (21%) completed bachelor's degrees in physics, and four (8%) completed degrees in other areas of science such as environmental science, wildlife management, or biochemistry.

Beyond the bachelor's degree level, many science teacher respondents also completed master's degrees. Fifty percent (n = 26) hold one master's degree, with 15% (n = 8) holding at least two master's degrees. Thirty-five percent (n = 18) completed master's degrees in science education and one teacher also completed a doctorate in science education. Six teachers (11%) have master's degrees in an educational area such as curriculum and instruction or teaching and learning, six teachers (11%) have master's degrees in chemistry, five teachers (10%) have master's degrees in biology, and four teachers (8%) have master's degrees in physics. One teacher reported elementary education, two teachers reported degrees in other areas of education, and two teachers reported administrative certification.

Because of the typical sequence of science courses, teachers who teach multiple courses may also teach at multiple grade levels. Twenty-one percent (n = 11) of the teachers instructed one grade level and 27% (n = 14) instructed one science course. Seventeen percent (n = 9) teach two grade levels and 27% (n = 14) teach two science courses. Thirty-one percent (n = 16) teach three grade levels and 29% (n = 15) teach three science courses. Thirty-one percent (n = 16) teach four or more grade levels and 17% (n = 9) teach four or more science courses. Forty-eight percent (n = 25) teach biology and 31% (n = 16) teach life science. Thirty-five percent (n = 18) teach physical science, 27% (n = 14) teach chemistry, and 21% (n = 11) teach physics. Thirty-one percent (n = 16) teach earth and space science and 19% (n = 10) teach environmental science. Twenty-nine percent (n = 15) teach other science courses such as Advanced Placement science or Anatomy and Physiology with 10% (n = 5) instructing general science courses.

When identifying their school district location, 46% (n = 24) reported that their school was in a rural area, 35% (n = 18) identified their school location as suburban or in a larger city, and 19% (n = 10) identified their school location as urban. Science teacher respondents also identified the service cooperative district that included their school district as indicated on Figure 1.

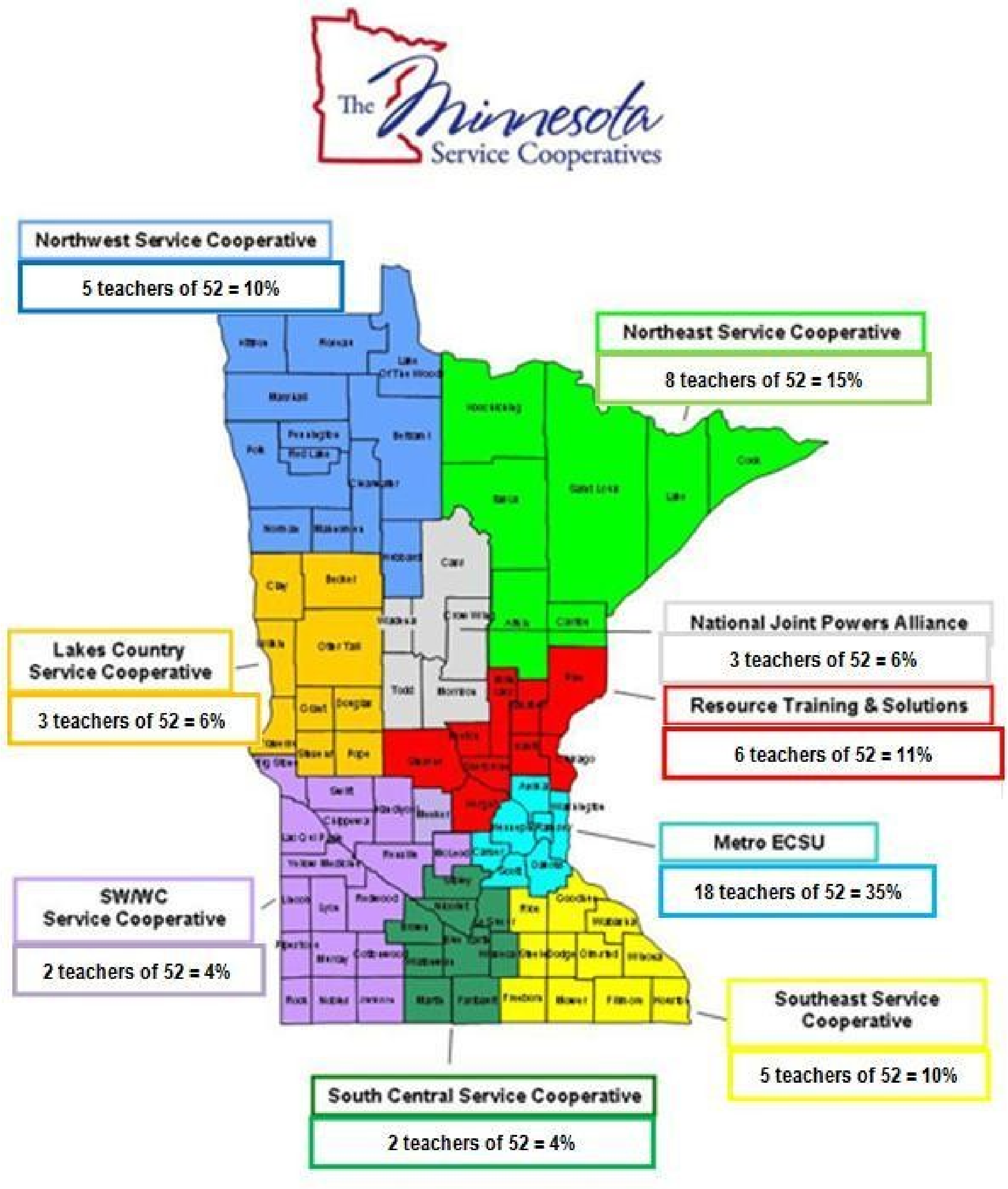

Figure 1. Distribution of Survey Respondents by Region. Adapted from Minnesota Service Cooperatives (2011). The Minnesota Service Cooperatives. Retrieved from http://www.mnservcoop.org/map.htm

Presentation of Quantitative Survey Results

Specific survey questions corresponded to the first two research questions and the related sub-questions. Survey questions 1–3, 5, 7, 9, and 10 (See Appendix A.) requested information about the components of high quality professional development. Survey questions 4, 6, and 8 were related to the types and formats of professional development opportunities including formal education and science activities, as well as informal activities. Survey question 21 related to research question 2a regarding intrinsic supporting factors for professional development participation and survey question 22 related to research question 2b about intrinsic inhibiting factors for professional development participation. Survey questions 11–15, 23, 25, and 27 related to the extrinsic factors supporting professional development participation including resources such as time, money, rewards, and location, as well as relationships with family members, teacher colleagues, and school administrations. Survey questions 16–20, 24, 26, and 28 related to the extrinsic factors inhibiting professional development participation which parallel the supporting factors. Research question 3 will be addressed in the results for the qualitative interview process.

High quality professional development participation.

High quality professional development is comprised of several different components including a relationship to district goals, relevance to teacher needs, job-embedded activities, and opportunities to improve the depth and breadth of content knowledge. A large percentage (94%, n = 58) of the science teachers participated in professional development related to district goals and76% (n = 47) engaged in opportunities driven by teacher needs. The integration of professional development activities into their school day was reported by 66% (n = 41) and slightly more than half (n = 32) were actively engaged in learning during their daily teaching practices. High quality professional development activities associated with science knowledge, skills, and science-related pedagogy were experienced by approximately half of the respondents. Table 1 presents the results regarding the components of high quality professional development.

Table 1.
High Quality Professional Development Participation by Teachers in the Past 12 Months

Components of High Quality Professional Development	n	Yes	Percent
Related to district goals	62	58	94
Driven by teacher needs	62	47	76
Integrated into the school day	62	41	66
Improved depth of content knowledge and/or skills for science	59	32	54
Actively engaged in learning during daily teaching practices	61	32	52
Sustained over time	60	29	48
Improved knowledge specifically on how to teach science content	61	28	46
Broadened content knowledge and/or skills in other science disciplines	60	27	45

Sustained professional development that continues over a period of time is an additional component of high quality professional development. Less than half of the respondents (n = 29) had participated in sustained professional development. As shown in Table 2, support continued over several months for 21 of the science teachers who responded affirmatively to the question regarding sustained professional development efforts. The remainder of the responding teachers received support for several days or several weeks beyond the initial professional development experience.

Table 2.
Time Period of Sustained Professional Development Support

Time Period	n	Percent
Several days after the initial learning opportunity	2	7
Several weeks after the initial learning opportunity	5	17
Several months after the initial learning opportunity	21	72
No response	1	3

Note. Respondents (n=29) were directed to this question after reporting participation in sustained professional development.

In addition, intensive opportunities which include many hours of professional learning experiences are also high quality professional development components. Less than 40% of the science teachers reported intensive (more than 33 hours) opportunities in formal activities in general education topics and approximately one-fourth reported more than 33 hours in areas of science topics. More than half of the science teachers reported intensive participation in informal activities related to general education topics (n = 37) and informal activities in science-related topics (n = 33). Table 3 includes the frequency counts and percentages of the related hours of participation by activity type. More distinctions between formal and informal activities and the related hours of participation will be discussed in the following paragraphs.

Table 3.
Annual Hours of Participation in Professional Development Activities

Hours of	Formal		Informal	
Participation	Education	Science	Education	Science
8 hours or less	9 (15%)	17 (30%)	2 (4%)	5 (9%)
9 - 16 hours	9 (15%)	13 (23%)	6 (11%)	8 (15%)
17 - 32 hours	18 (31%)	12 (21%)	10 (18%)	8 (15%)
33 or more hours	23 (39%)	15 (26%)	37 (67%)	33 (61%)
Total	59 (100%)	57 (100%)	55 (100%)	54 (100%)

Note. The number of respondents varied by question.

Types of professional development activities.

Formal professional development activities for general education topics provide opportunities to expand knowledge and skills in areas of teaching and learning and generally involve a more prescribed, prearranged schedule of events such as workshops and courses. The majority of the science teacher respondents (n = 56) had participated in school-based in-services and approximately three-fourths (n = 43) had participated in off-site workshops occurring outside of their districts. Less than half had participated in mentoring or peer coaching and a similar percentage took part in research conferences or seminars. Additional data are available in Table 4.

Table 4.
Formal Activities for General Professional Development

Activity	n	Yes	Percent
School-based inservices	59	56	95
Off-site workshops	59	43	73
Mentoring and / or peer coaching	59	26	44
Observations of local district colleagues	59	23	39
Research conferences or seminars	58	19	33
Formal college or university course for credit	59	13	22
Online courses	59	10	17
Observation visits to other schools	59	8	14

Formal science professional development provides opportunities in a formal context that are directly related to science content knowledge and skills, as well as how to teach science content. Over half of the science teacher respondents (n = 33) reported participation in off-site workshops on science teaching and in study groups with local colleagues to discuss science teaching issues. Forty-two percent (n = 24) observed other teachers teaching science and 39% (n = 22) mentored or peer coached other science teachers. Smaller percentages of science teachers reported participation in university science or science education courses, online professional development, scientific research conferences or seminars, or science teacher association meetings at the state or national level. More detailed information is presented in Table 5.

Table 5.
Formal Activities for Science Related Professional Development

Activity	n	Yes	Percent
Off-site workshops on science teaching.	57	33	58
Study groups with local colleagues to discuss science teaching issues	57	29	51
Observations of other teachers teaching science	57	24	42
Mentoring and/or peer coaching in science teaching	57	22	39
Scientific research conferences or seminars	57	13	23
Formal college or university science course	57	9	16
Online professional development for science teaching	57	7	12
National or state science teacher association meeting.	57	7	12
Formal college or university course in the teaching of science	57	6	11

Informal professional development activities occur in a less formal context and encompass a wide variety of personal and collaborative opportunities. Over 90% of the respondents reported participation in several informal activities: searching the Internet, attempting new ideas through trial and error, reflecting on their actions, talking informally with colleagues about how to improve teaching, and sharing materials and resources. Other informal activities such as reading professional literature, networking with teachers from other schools, and researching independently or collaboratively were also practiced by well over half of the respondents. Table 6 displays the actual percentages of participation in these informal activities.

Table 6.
Informal Activities for Professional Development

Activity	n	Yes	Percent
Searching the Internet	55	54	98
Attempting new ideas through trial and error	55	54	98
Reflecting on your actions	55	54	98
Talking informally with colleagues about how to improve your teaching	55	51	93
Sharing materials and resources with others	55	50	91
Reading professional literature (e.g. journals, thesis papers, etc.)	55	44	80
Networking with teachers from other schools	55	38	69
Researching individually or in collaboration with others	55	33	60

Supporting intrinsic factors.

A list of possible intrinsic factors that supported professional development participation was collected from research described in the literature review of Chapter 2. With a total of 54 science teachers responding, fifty percent (n = 27) listed a desire to learn more as the most supportive intrinsic factor and 39% (n = 21) reported that a desire to help students was the most supportive intrinsic factor. Other supportive intrinsic factors selected were at levels below 10%: self-initiative (6%), enthusiasm (4%), and a desire to be a more effective instructor (2%).

Inhibiting intrinsic factors.

In a similar fashion with 54 science teachers also responding, intrinsic factors that did not support or inhibited professional development participation were compiled from the literature review research sources. Stresses related to different personal situations accounted for over half of the responses, with the stress of a heavy workload selected by 41% (n = 22) and the stress of family or outside obligations selected by 19% (n = 10). The remaining choices were typically selected at levels slightly above or slightly below

10% of the respondents, with all available options listed by order of their frequencies in Table 7.

Table 7.
Inhibiting Intrinsic Factors: Frequency of Response (n=54)

Inhibiting Intrinsic Factors	Frequency	Percent
Stress of heavy workload	22	41
Stress of family and / or outside obligations	10	19
Changes in teaching assignments (larger classes, new grade level, different subject)	6	11
Lack of information about professional development opportunities	4	7
School policies do not seem to support changes in classroom activities	3	6
Professional development learning does not seem to be supported by administrators	3	6
Mental and / or physical exhaustion	2	4
Student behavior does not seem to change	2	4
Other (Lack of interest due to quality of offerings)	2	4
Lack of self-confidence	0	0

Supporting extrinsic factors.

Upon review of the literature resources describing the extrinsic factors supporting the participation of teachers in professional development activities, the researcher combined the factors into two categories: resource-related factors such as available time, available money, other rewards, or accessible locations; and external relationships with family members, teacher colleagues, students, or school administrators. The resource-related factors will be discussed first in the following paragraphs.

Over half of the 53 science teachers reported that available time was the most supportive resource-related factor and approximately one-fourth selected available money as most supportive. Non-monetary rewards and the distance to professional development opportunities were selected by less than 10% of the teacher respondents. Table 8 presents the actual percentages for each of the supporting resource-related factors.

Table 8.
Resource-Related Supporting Extrinsic Factors: Frequency of Response (n=53)

Supporting Extrinsic Factors	Frequency	Percent
Available time	35	66
Available money	11	21
Non-monetary rewards	4	7
Distance to professional development opportunities	3	6

Note. Respondents were directed to specific secondary questions related to the selected resource-related factor to discern related sub-factors.

After selecting one of the resource-related factors, survey respondents were directed to a secondary question in which they rated more specific supportive sub-factors related to the resource they selected. The ranked responses were weighted during the analysis process with the most supportive favorite multiplied by three, the second most supportive factor multiplied by two, and the third most supportive factor multiplied by one. The data description for these specific factors will include the most frequent option selected for the most supportive factor, as well as the most selected options overall.

Of the 35 teachers who selected available time as the most supportive factor, 32 teachers ranked at least one factor. The availability of release time for professional development participation was most often ranked as the most supportive factor by 12 science teachers, as well as one of the most selected responses when the totals for all three rankings were combined. Time away from school or classroom responsibilities was ranked as the most supportive factor by seven teachers and also one of the most selected responses with the totals for all three rankings combined. Ten teachers selected time away from family responsibilities as the most common second most supportive factor and was the third most selected response with all three ranked items combined.

Ten teachers selected available money as the most supportive factor for their participation in professional development. Three teachers selected school or district paid substitute teacher salaries as their number one ranked choice. School or district paid registration fees was most commonly chosen as the second ranked choice (n = 6) and was the most selected response with all three ranked items combined. Overall, half of the teachers completing this question selected travel and/ or lodging reimbursements as one of the top three most supportive factors relating to available money.

Non-monetary rewards was selected as the most supportive factor by four teachers. Opportunities to meet new people, free curricular materials, recognition by the school administration or community, and opportunities to travel were the most highly ranked factors for this secondary question. Opportunities for leadership roles, free non-curricular books, and opportunities to fulfill license requirements were also selected, but were ranked at lower levels.

Distance to professional development opportunities was selected by three teachers as the factor most supportive of their professional development participation. Opportunities that are within a reasonable driving distance was selected as the most supportive factor and was the highest choice with the three ranked items combined. Proximity to colleagues, proximity to technology resources, and proximity to community resources are listed in the order of their overall combined rankings.

Extrinsic factors connected with the external relationships involving teacher colleagues, school administrators, and family members were also explored. Table 9 displays the percentages of science teachers who experienced specific types of supporting relationships. Over half of the science teacher respondents (n = 33) received collegial support, as well as recommendations for professional development opportunities. Less than one-fourth of the science teachers (n = 12) chose to pursue off-site participation on their own due to isolation from colleagues and a similar number (n = 11) experienced subtle pressure to participate in professional development opportunities.

Relationships with school administrators regarding professional development are often connected to school initiatives. Almost 90% of the science teachers reported that the school-based professional development is related to school goals. Over half of the science teachers (n = 34) reported that access to effective professional development is provided by administrators and a similar number (n = 28) stated that administrators provide flexible scheduling for professional development. Less than 50% (n = 23) reported that shared decision-making was utilized for professional development issues.

Specific family members were not designated by the survey but the category was meant to include significant others, children, parents, or any other family members involved in the life of the science teacher. A large majority of science teachers (90%) reported that family members encouraged personal growth and 80% stated that family members helped to balance work and family time. Over half (67%) reported that the routines of family life promoted the opportunity to participate in the variety afforded by outside professional development activities.

Table 9.
Relationships with Teachers, School Administrators, and Family Supporting Professional Development

Type of Supporting Relationship	n	Yes	Percent
From Teacher Colleagues			
Colleagues offer recommendations for professional development	54	33	61
Colleagues offer support or peer coaching	54	33	61
Isolation from colleagues promotes off-site participation	53	12	23
Colleagues provide subtle pressure to participate	54	11	20
Interpersonal conflicts with colleagues promote self-initiated learning	54	3	6
From School Administrators			
School-based professional development is related to school goals.	53	47	89
Administrators provide access to effective professional development.	52	34	65
Administrators provide flexible scheduling for professional development.	53	28	53
Shared decision-making powers are used for professional development issues.	53	23	43
From Family Members			
Family members encourage personal growth.	51	46	90
Family members contribute to balancing work and family time.	51	41	80
Professional development provides opportunities for variety outside of family life.	51	34	67

Inhibiting extrinsic factors.

Similarly to the supporting extrinsic factors, the categories of resources and relationships gleaned from the literature review were utilized. In the case of the resource-related factors, the absence of a resource was often an inhibitor. Just as available time was a supportive factor, the lack of available time was designated as an inhibitor by 61% (n = 32) of the science teachers. Thirty-one percent (n = 16) selected the lack of available money as the most inhibiting factor toward their professional development participation. Six percent (n = 3) chose distance to professional development opportunities as the most inhibitive and one teacher explained that the lack of available time, the lack of available money, and the distance are all equal factors inhibiting participation. The lack of non-monetary rewards was not selected by any survey respondents as an inhibiting factor. Table 10 presents the frequency counts and percentages.

Table 10.
Resource-Related Inhibiting Extrinsic Factors: Frequency of Response (n=52)

Inhibiting Extrinsic Factors	Frequency	Percent
Lack of available time	32	61
Lack of available money	16	31
Distance to professional development opportunities	3	6
Other (Lack of time, lack of money, and distance are equal)	1	2
Lack of non-monetary rewards	0	0

Note. Respondents were directed to specific secondary questions related to the selected resource-related factor to discern related sub-factors.

Science teachers who selected one of the extrinsic resource factors were directed to a secondary question to rank sub-factors specifically related to that resource. Of the 32 teachers who selected the lack of available time as an inhibitor, 14 ranked the time needed to prepare for substitute teachers as the most inhibitive factor and 10 ranked time spent away from family and friends as the most inhibitive and those selections remained in the same ordered ranking when the totals for all three rankings were combined. In addition, the time required for school-related, non-teaching duties and the time required to travel to off-site locations, as well as the time required to create accommodations for students were also commonly selected when the totals for all three rankings were combined.

The lack of available money as the most inhibiting factor was selected by 31% (n = 16). For those 16 teachers, the majority (n = 11) ranked the lack of district funding for professional development costs as the most inhibiting factor and this factor was also the most selected overall when the totals for all three rankings were combined. Personal financial costs incurred for travel and lodging expenses or for professional development registration fees were the second and third most commonly selected factors when comparing the totals for all three rankings combined.

The distance to off-site locations was selected by three teachers as an inhibiting factor. The most common inhibiting factor was the actual distance to the off-site professional development activities. The lack of proximity to technology resources, community resources, and school department offices were also selected as inhibiting factors related to distance.

Relationships with teacher colleagues, school administrators and family members may also inhibit professional development participation. Table 11 depicts the combined information for each relationship group. Less than one-fourth of the science teachers (n = 13) reported that isolation from teacher colleagues inhibited relationships and less than 10% (n = 5) listed interpersonal conflicts as an inhibiting factor. Over 50% of the science teachers reported inhibiting relationships with school administrators in the areas of limited decision-making powers related to professional development (n = 30) and the lack of flexible scheduling for professional development (n = 28). Less than half (34%) selected the lack of access to effective professional development by school administrators and less than one-fourth (17%) are required by school administrators to participated in professional development that is not related to school goals.

As for family relationships, the inhibiting factors are at much higher levels. Seventy-five percent of the science teachers (n = 39) reported that professional development participation was inhibited because home schedules were disrupted or because participation caused difficulties in balancing work and personal time. In addition, 62% (n = 32) indicated that professional development participation was inhibited because too much time would be spent away from family events. Less than 50% of the science teachers listed difficulties with childcare or financial strains caused by participation as inhibiting factors.

Table 11.
Relationships with Teachers, School Administrators, and Family Inhibiting Professional Development

Type of Inhibiting Relationship	n	Yes	Percent
From Teacher Colleagues			
Isolation from colleagues inhibits relationships.	54	13	24
Interpersonal conflicts with colleagues inhibit supportive relationships.	54	5	9
Colleagues provide too much pressure to participate.	54	0	0
From School Administrators			
The decision-making powers of teachers for professional development is limited.	53	30	57
Flexible scheduling for professional development opportunities is not provided.	53	28	53
Access to effective professional development resources is not provided.	53	18	34
Compulsory, school-based professional development is not related to district goals.	53	9	17
From Family Members			
Participation causes disruptions to home schedules.	52	39	75
Participation causes difficulties balancing work and personal time.	52	39	75
Participation means too much time is spent away from family events.	52	32	62
Participation causes difficulties with childcare arrangements.	52	25	48
Participation causes undue strains on family finances.	52	18	35

Data Analysis-Qualitative Interviews

Thirty-five survey respondents were willing to participate in follow-up interviews to triangulate individual experiences of science teachers with the data compiled from the survey. The demographic information of these thirty-five teachers was sorted in an Excel file primarily according to their years of teaching experience and, secondarily, by their school location (rural, suburban, or urban), and thirdly, by the sciences courses taught. Initially, six teachers were selected and contacted through their preferred form of communication, an email message. Positive replies were received from three of the six teachers and interviews were scheduled and conducted. Alternate teachers from missing levels of teaching experience and within a reasonable traveling distance were contacted and two more interviews were scheduled and conducted for a total of five completed interviews. To protect the confidentiality of their identities and their interview responses, the science teachers participating in the interview process were designated by pseudonyms based on the military alphabet (Alfa, Bravo, Charlie, Delta, and Echo) in interview notes and transcription files.

Participants-Qualitative Interviews

The participants in the qualitative interview process comprised a wide range of teaching experiences. The number of years in the teaching profession ranged from 10 years to 35 years. The interviewees all held licenses in life science teaching and several also held licenses in other areas such as earth and space science or physical science. The grade levels of the students instructed by the science teachers ranged from seventh and eighth grades to the high school grades of nine through twelve. All of the science teachers interviewed began teaching in different districts before moving to their current district, where they spent the majority of their teaching career. The location of the district for their current teaching assignment ranged from very small districts in rural areas to larger districts in small cities of rural areas to very large, urban districts.

Alfa teaches 7^{th} life science and a combined earth science / physical science course for 8^{th} graders in a very large, urban district. Bravo teaches biology and chemistry to students in grades ten through twelve for a large city district in a rural area. Charlie teaches 9^{th} grade physical science and various science disciplines for alternative school students in grades ten through twelve in a very small district in a rural area. Delta teaches 8^{th} grade earth and space science and 9^{th} grade physical science in a small school district in a rural area. Echo teaches biology, chemistry, and anatomy and physiology courses to students in grades ten through twelve for a large city district in a rural area.

Presentation of Qualitative Results

Open coding was employed to find the statements of meaning within the interviewee responses from the semi-structured interview. The themes that emerged from the open coding process also related to the themes of the quantitative survey:

- Professional development activities (quality, relevance, education, science)
- Resources (time, funding, distance, technology, equipment)
- Relationships (family, colleagues, administrators, community, students)
- Personal intrinsic factors (interest, choices, desire to learn, helping students)

Since questions 1 through 4 related to demographic information, the actual interview questions related to research question 3 began with interview question 5. Interview questions 5 and 6 asked the science teachers to define professional development and to explain the purpose for professional development. Interview questions 7 through 13 were related to the professional development opportunities available to the science teachers which also correspond to Research Question 1. Interview questions 12 and 13 also asked about the professional development needs of the science teachers and how they met those needs. Interview questions 14–16 were related to the factors that may affect their decisions about participation and their participation in professional development opportunities.

Professional development qualities.

During the interview teachers were first asked about the definition and purpose of professional development. The teachers' responses were in agreement that professional development includes any type of learning that improves their teaching, both in science and general pedagogy. Their comments about the purpose of professional development were related to the definition, since their professional learning was meant to help their specific students be engaged and learn more.

The quality of professional development available to the interviewed science teachers was easily discerned from their statements. The teachers preferred and enjoyed self-selected, experiential activities that were relevant to their students' needs, their classrooms, and their teaching objectives. However, most often such activities occurred outside of their own school district and required the use of their own funds or took place during non-contractual times such as during the summer months. Professional development activities occurring within the school district, although considered quality opportunities, were mandated by the school administrative policies. These compulsory activities covered general education topics that would relate to all teachers such as requirements for relicensure or embedding academic standards. Professional development that concentrated on the improvement of science teaching and learning was typically not offered within their own school district.

Alfa commented:

> I feel like sometimes they're going for sort of the lowest common denominator, so a lot of times it takes like halfway through the training

> before there's any real meat to it that applies to a lot of us taking it. So not a lot of differentiation, which is the big key word now for all schools.

Bravo also commented:

> In the area of science, only those that I seek out or get fliers for or emails about. By the district, the district does offer workshops in reading in the content area. Those necessary ones for licensure. They generally, however, do not do specifically science topics. It's more focused on what is being tested by the state.

Delta stated:

> They are not as science-based as I would like. I think I would have to do a lot more searching to find science activities that I would find beneficial.

Echo commented:

> I compare the relevance to my science teaching needs. The district ones aren't as relevant and are required, so they are not as useful as things for content.

When asked about their specific participation in professional development opportunities, the interviewed teachers most often mentioned formal activities. The science teachers participated in school-based in-services, half-day or full day workshops at off-site locations, college or university coursework, and summer institutes. The off-site professional development providers included local educational service cooperatives, other governmental agencies, university-sponsored groups, science research organizations, science teaching organizations, and vendors for science equipment.

Because of the content and personal choices involved, the teachers find the opportunities outside of their district more engaging and enjoyable.

Alfa commented:

> Those [professional development activities occurring outside of the district] I generally enjoy more because I have to pay for them. They are almost always college courses. I can more easily select exactly what I need. So, there's the usual ebbs and flows with every class, but I can tailor things more to my own needs.

Charlie commented:

> …it's something that I've chosen that I want to do, so overall I find that a lot better, you know. And, generally, it's something that I can take back with that question [about off-site professional development], it's something that I can take back and use, whereas in question 9 [about district-based professional development], it's something I can't use.

Informal professional development activities were often mentioned as ways in which teachers updated their scientific knowledge on their own or gathered new information about science teaching. Reading about science topics in traditional printed formats such as newspapers, textbooks, magazines, and journals, as well as through online sources were informal practices commonly used by the teachers. Other technology resources such as email communications and Internet searches were also used to gather information about classroom topics and professional development opportunities. A few of the interviewed teachers also mentioned travel excursions, either with students or with families, as an important source of informal learning to assist their classroom teaching perspectives. Trying new things with students and using an "action research" approach of trial and error in the classroom were other informal practices utilized by the teachers.

Since the nature of science is tentative and ever-evolving, new explanations of phenomena are being presented in rapid succession. The interviewed science teachers discussed the constant change in science and the necessity to stay current with science knowledge and skills. The interviewed science teachers expressed the importance of such opportunities, especially in the areas of genetics, biotechnology, brain research, water quality, and technology integration.

Bravo commented:

> Wow! There's so much change in science. Just trying to keep somewhat up-to-date. And it's really those cutting edge things that get, that peak the kids' interests. My biology class where I always try to pull things out of, like, science news, or if there is something in the paper related to what we are talking about. "See. It's even in the newspaper." To try to peak their interest more.

Delta stated:

> So, keeping up with the newest discoveries and the newest innovations in our field is really important, because the stuff that makes the news is the stuff that kids want to know about. You know, "How does that work?" Or …those are things that I like to keep up with and we get so bogged down

> in standards that, you know, I think the little stuff where…to make it real for kids, I think we have to try to keep current.

Echo indicated:

> I like the workshops such as "Monarchs in the Classroom" or "Brain U". They are pre-packaged, but they have lots of knowledge and are content-related.

Resources–time, money, distance.

The availability of resources such as time, money, and accessible locations were factors that affected the professional development participation of the interviewed science teachers. All teachers mentioned these factors, although individual teachers provided more emphasis on specific factors that affected their personal situations. Some teachers also described their professional development experiences by grouping resource factors such as funding and time together.

Time.

Time is another resource-related factor that was discussed by the science teacher interviewees. The availability of time affected participation in formal and informal professional development activities, as well as interacted with other resource and relationship factors. Science teachers required time to participate in off-site activities and requested time to reflect on the professional development opportunity, although time out of the classroom may be discouraged by personal preferences or by administrative policies. In addition, time spent in professional development endeavors would mean time spent away from family members. Lack of time affected informal reading opportunities which led to cancelled subscriptions. Many teachers were involved in extra-curricular activities with students or family members and contributed to school initiatives and committees, which reduced the amount of time available for professional development or to even find helpful professional development opportunities. The continued lack of time for professional learning efforts eventually led to feelings of being overwhelmed for some science teachers.

Alfa commented:

> Do I have time to add anything new? Summertime is a good time to do things. I have 2 kids. I was on 6 committees that did take a lot of time. Really, just overbooking myself [hindered learning efforts].

Bravo stated:

> We have always said that we need a day after a workshop to figure out where that's going to go and how we can incorporate things.
>
> The time aspect. It is, you know, it's tough to be gone, like to a workshop during the day. So time to actually go was appreciated. Time to synthesize and incorporate would be very appreciated. And the lack of that time is very hard.

Charlie indicated:

> …you get just inundated with stuff; it's in the middle of summer. You don't have time to really process it and see how it would fit.

Delta expressed:

> We only have a certain number of hours that we can devote to PD and it's what do most people need for relicensure, because all of our staff development is usually together and I think we only have 3 or 4 days a year in our contract for PD. And then, it's getting ready for school and cleaning up after school, and I think we have actually just two during the year.

Money.

The availability of funding for professional development can be an incentive as well as an inhibiting factor. Some teachers mentioned that they preferred not to spend their personal funds on professional development, but when personal finances were used toward self-selected opportunities, the teachers found those opportunities more relevant and beneficial toward their own learning. Stipends for district–wide professional development were considered an incentive to attend, but not always at an engaged level of participation. Federal funding for science teacher professional development opportunities were mentioned by the two teachers with more years of teaching experience (over 25 years).

Bravo commented:

> I have been lucky enough to be old enough that I had the opportunity to take advantage of Eisenhower funds to attend national and regional science teachers, NSTA, conferences which for the science side of my job were vital. They were absolutely wonderful. Of course, now, with the

> budgetary concerns, we do not have those opportunities anymore. Even with district monies, you can't go anymore.

In addition, Bravo stated:

> Not having that national funding like we used to have for the science teachers really hurts us. Because the district does not get enough funding for us to attend those kinds of workshops. They'll bring in the general ones that they know everybody needs, but those specific science or the specific things for science are not there. There just isn't enough money to do that. That's a big hindrance.

Delta stated:

> I just think there's a lot of good science PD out there, but it's so hard to access it with, you know, with lack of school funding and, truthfully, time.

Echo indicated:

> Money is a big thing. Having more opportunities to fund teacher professional development like the NSF and other groups made it much easier to do.

Distance.

The inhibiting factors of distance to off-site locations and the isolation of rural areas were mentioned by the science teachers from the rural schools. Science teachers in rural locations contended with long distances to off-site professional development opportunities. Professional development activities that were offered regionally still required transportation to the facility, which also included the driving time to traverse that distance. In addition, the rural science teachers explained that professional development providers for science do not travel to the rural locations and the most relevant college courses offered during the summer were often located in the Twin Cities rather than at more regionally located institutions.

Bravo indicated:

> I have to go looking for my science ones. They generally don't come here.

Charlie stated:

> Unfortunately, it's distance, when, what time of the year is it, cost. The fact that I'm doing, I'm thinking about that is that I'm thinking that it's going to be something that I would find helpful. And then whether or not they would…I could get time off to go attend it, if it was during the year.

Delta commented:

> I'm waiting for more things that would be applicable to this region, instead of traveling to the Cities or to Fargo,

Relationships.

Administrators.

Administrative support for resource allocation, especially time and money, was an important factor. Even in the absence of resources, supportive administrative relationships had a strong bearing on other supporting and inhibiting factors such as relationships with other teacher colleagues and intrinsic factors related to morale and personal motivation. Administrative policies affected the prospects for flexible scheduling for collegial interactions, the quality of district professional development offerings, and the level of choice available to teachers for off-site activities.

Bravo stated:

> Around here they [school administrators] do as much as the budget will allow.
>
> One of the things that our district, I feel, has a problem with is they don't think anyone within the district has expertise for it to be professional development. It seems that they need to go outside of the district, which I think is not always the case.

Charlie commented:

> So, that's typical with that district is that we have all this and you spend all this and then it comes back that we're spending all of this money on you guys to do this. Well, yeah, but, you know, you don't let us…you don't follow it up. And, you know, you don't let us work it, process it, you know, and talk amongst ourselves.
>
> I know in our area, we're not able to get common prep times.
>
> They're kind of frowning on you going to professional development stuff in the middle of the school year.

Colleagues.

Often related to the administrative policies, relationships with colleagues were affected by the allocated time for collegial interactions, as well as the overall vision of job-embedded opportunities such as professional learning community

(PLC) groups. Elementary teachers and high school teachers worked together in PLCs, but not usually surrounding science-related issues. Administrative changes in teaching assignments had an adverse effect on certain relationships. In addition, administratively selected collegial groups may not be as productive as self-selected collegial groups that offer a higher level of trust and treatment as a professional educator.

Charlie stated:

> We just showed up and didn't know where we were going to be teaching, didn't know what we were going to be teaching, like, not even the week before. School started and then we get to the school and there's…nobody. Nobody greeted us. Nobody said, "Hey, you know, I'm glad you're with us."

Delta commented:

> Well, I think that if I surround myself with the right people, that is very helpful. But when I surround myself with colleagues that absolutely will not change, that's hard. I think that things that help me learn are collaboration with people who I trust.
>
> We try to not outsource people, but to use experts within our own district and I think that people get so much more out of that than having somebody come in for lots of money and talk to you about it.

Family.

Relationships with family members, especially children, affected professional development participation. Science teachers with older children became more involved with the children's interests and professional development that interfered with family time were avoided or not utilized.

Charlie indicated:

> I haven't been able to do that [participate in a specific professional development program] because of conflicts because it's only during the summer and a few days, a weekend day or something on the weekend in the middle of the year and with hockey and stuff, it's like ,"Nope." I've since dropped out of that.

Echo stated:

> It was easier to participate in professional development when my children were younger [but, school-aged].
>
> When they were older, they [children] became more active in programs and extra-curricular activities. And it was much easier to travel with the kids when they were older for family trips during the summer. [rather than attending summer workshops or classes].

Personal intrinsic factors.

The interviewed science teachers expressed the personal desires to learn more in order to help their students. In addition, the amount of personal choices given for professional development selections affected the science teachers' attitudes toward the quality and relevance of the activities. The relationships with school administrators and the climate of the school environment also affected the personal motivations of the science teachers.

Charlie commented:

> Right now the motivation or the morale in the district is very, very low among all the teachers and stuff. I remember when I first started it was…they would have potlucks all the time. They would…People would be getting together all of the time. Now, it's just, you get done, you go home.
>
> You know, also motivation too. I get done and at the end of the day and it's like "I'm done." It's like…I used to bring homework, work home, but I don't need to do that anymore.

Delta stated:

> I can take a bunch of classes, but if I don't do any reflection with it or I don't apply it, it's not developing my teaching at all.
>
> Being a part of the learning process, instead of listening to someone dictate. I don't usually choose to do those things.
>
> The other things are actually doing the activities that the kids would do and I think by doing that it makes me understand how I want to make my lessons and how I could make it work in my classroom. But, it has to be activity-based.

> Well, I think this has maybe helped and hindered, but fear of change. That you just get used to one way of doing things and then it's completely flipped on top. You know, flipped on its top and…but that's good in a way too, because if you don't change you kind of get stuck in the…I call it the "read the book and answer the questions". But my one personal one is fear of change. And then I think also things that have helped is always wanting to be on the cusp of new things and ways to keep kids interested or ways to keep involved and wanting to learn about science. So, I think fear of change is good and bad, but also the wanting to be on the edge and do something different than I did the year before. I can't stay doing the same thing all the time. I can't. And so that maybe is helpful too. I get bored.

Echo expressed:

> It helped that I like to learn and stay on top of new things. I get a personal satisfaction to improve my teaching.
>
> I think it depends on personal goals. Teachers can take advantage of opportunities if they choose. Professional development has been available.

Summary

This chapter described the quantitative and qualitative data collected from highly qualified Minnesota science teachers of grades five through twelve regarding their professional development experiences. The results of the quantitative survey indicated that available time was the most supporting resource-related factor while the lack of available time was the most inhibiting resource-related factor. The data from the qualitative interviews also supported these findings, describing time and funding as the most influential factors relating to professional development participation. Supportive relationships with school administrators, teacher colleagues, and family members were identified as vital elements for science teacher participation in professional development. Personal intrinsic factors such as the desire to learn more and the desire to help students were also designated as supportive factors for science teacher participation in professional development activities, while the stresses of heavy workloads and obligations based on family needs or other outside entities were the most inhibiting factors. The next chapter will describe the findings and recommendations based on the results, as well as implications and possibilities for future research.

Chapter 5. Findings and Conclusion

Introduction

The continued importance of professional development in our current teaching environment is exemplified by Guskey and Huberman‘s (1995) quote:

> Never before in education has there been greater recognition of the need for ongoing professional development. In-service training and other forms of professional development are a crucial component in nearly every modern proposal for educational improvement. Regardless of how schools are formed or reformed, structured or restructured, the renewal of staff members' professional skills is considered fundamental to improvement (p. 1).

Research Questions

This research study explored professional development for Minnesota science teachers through the following three research questions and the corresponding sub-questions:

1. In what types of professional development do experienced, highly qualified, secondary science teachers in Minnesota engage?
2. What factors influence their decision to participate in any type of professional development activities?
    a. What intrinsic factors promote participation?
    b. What intrinsic factors inhibit participation?
    c. What extrinsic factors promote participation?
    d. What extrinsic factors inhibit participation?

3. How do experienced, secondary science teachers describe the factors that affect their professional development experiences?

The discussion of the results will be organized according to categories related to these research questions with the qualitative interview data triangulated with the quantitative survey data. The categories used are connected to the themes presented in chapter 4: the types of professional development, supporting and inhibiting intrinsic factors, supporting and inhibiting extrinsic factors (such as resources and relationships), and the interactions between and among the intrinsic and extrinsic factors. The types of professional development section discusses high quality professional development, including both formal and informal activities relating to research question 1, as well as the descriptions of experiences for research question 3. The intrinsic factors that support and inhibit professional development participation are discussed in the next section and relate to sub-questions a and b of research question 2 and the described experiences for research question 3. Sub-questions c and d of research question 2 are addressed by the discussing the supporting and inhibiting extrinsic factors including resource-related items and external relationships that help describe the professional development experiences for research question 3. The interactions between and among the intrinsic and extrinsic factors connect with research question 2 and it's sub-questions, as well as containing references relating to research question 1 and research question 3.

Types of Professional Development

Loucks-Horsley et al. (2010) in their book, *Designing Professional Development for Teachers of Science and Mathematics* suggested on page 5 that:

> ….there is widespread consensus regarding what constitutes effective professional learning: It is directly aligned with student learning needs; is intensive, ongoing and connected to practice; focuses on the teaching and learning of specific academic content; is connected to other school initiatives; provides time and opportunities for teachers to collaborate and build strong working relationships; and is continuously monitored and evaluated. Despite the improvements made in teachers' professional learning that reflect what is known to be effective professional development; the challenges are greater than ever.

Both the quantitative survey data and the qualitative interview results indicated that science teachers were participating in both formal and informal professional development opportunities with high quality components. Aspects of job-embedded professional development were evident with science teachers participating in formal activities that were integrated into the school day; however the same level of participation was not reported regarding the active engagement in learning during daily teaching practices as suggested by Garet et al. (2001) and Croft, Coggshall, Dolan, Powers, and Killion's (2010) definitions for job-embedded professional development. In addition, science teachers participated in high quality professional development that was related to district goals and driven by teacher needs, but, as the interviewed science teachers explained, the district goals and teacher needs were usually related to general education topics such as differentiated instruction or classroom management, re-licensure requirements like reading in the content areas or mental health, or technology integration that would apply across the board to most teachers. Such findings agree with the compelled professional development activities discussed by Knight (2000), Schibeci and Hickey (2004), Scribner (1999), and Wan and Lam (2010). Informal learning strategies were used often by science teachers to update their content depth and breadth which related to the findings of Lohman in 2006. As explained by the interviewed science teachers, more “cutting edge” science-related professional development was typically not offered through district-wide professional development events and usually occurred at off-site workshops or summer institutes with expenses often paid by the teachers. Such opportunities were only considered successful about half of the time in improving science knowledge and skills or scientific pedagogical content knowledge according to the quantitative survey data, although the interviewed science teachers appreciated that participation in the off-site activity was their own choice which ties in to Schibeci and Hickey’s (2004) dimensions of autonomy.

In addition, Loucks-Horsley et al. (2010) suggested specific strategies for science teacher learning to address the specialized content knowledge and pedagogy required for science teachers. Recommended activities that immerse science teachers in content, standards and research such as university science or science education courses were only attended by less than 20 of the surveyed of science teachers. More formal professional development structures such as workshops and study groups were utilized by at least half of the surveyed science teachers, although online professional development was underutilized with less than 10 surveyed teachers participating. Activities involved in examining teaching and learning such as mentoring or peer coaching in science teaching were practiced by about 20 of the surveyed science teachers, but less formal and more personal strategies like attempting new ideas through trial and error or reflecting on their actions were used by almost all of the surveyed science teachers. Therefore, a framework for informal science-based professional development based on the Loucks-Horsley et al. (2010) suggestions are present, but more formalized, job-embedded strategies for science teaching are still only performed about half of the time according to survey responses.

High quality professional development should be collaborative, as well as job-embedded. The surveyed science teachers were involved in some observations of other teachers, including science teachers, as well as mentoring or peer coaching in science teaching, similar to the opportunities described by Sparks (2005). Science teachers also discussed science teaching issues with local colleagues in study groups, although the lack of science-related discussions occurring in professional learning communities (PLCs) with elementary teachers was a source of frustration for the interviewed secondary science teachers.

Although more science teachers experienced collaborative efforts for professional development, some science teachers were still isolated from district colleagues and peers in other school districts. Elmore's (2002) statement that "teachers are still, for the most part, treated as solo practitioners operating in isolation from one another under conditions of work that severely limit their exposure to other adults doing the same work" (p. 4) was a concern also expressed by the interviewed science teachers. Moreover, rural science teachers, in their survey responses, reiterated their compounded isolation because they may be the only science teacher in the building teaching who must teach multiple courses at multiple grade levels, similar to the findings of Wilson & Ringstaff (2010), but the rural science teachers of Minnesota participating in the survey had more specialized science degrees than the general science degrees suggested by Monk (2007). If science teachers are the single content provider in their school, they should still have networking opportunities with teachers from other schools since "almost all schools can benefit from interacting with practitioners from other schools" (Sparks, 2005, p. 17), but observation visits to other schools were not a highly-utilized professional development strategy according to the survey results.

High quality professional development should also include learning efforts that are sustained over time and intensive in actual participation hours. Professional development strategies that involved more than 50 hours of support beyond the original experience resulted in better student achievement (Wei et al., 2010), but approximately only one-third of the science teacher respondents participated in professional development that was sustained over several months. In addition, although over half of the science teachers performed informal professional development approaches for more than 33 hours to improve their science knowledge, only about one-fourth used formal activities related to science, when over 50 hours of high quality professional development are recommended to improve skills in order to assist student learning (Wei et al., 2009). The science teachers who were interviewed expressed their preference for longer summer institutes for deeper learning.

Another component of high quality professional development includes relevant, practical experiences that are driven by teacher needs. Lieberman in 1995 stated that "what everyone appears to want for students–a wide array of learning opportunities that engage students in experiencing, creating, and solving real problems, using their own experiences and working with others – is for some reason denied to teachers when they are learners." (p. 591). A similar remark was expressed by Alfa, a science teacher interviewee, "We differentiate for learners, but they don't differentiate for us. I guess maybe ironic would be a good descriptor" (personal communication, January 26, 2012). References to the quality of the professional development offerings and their relevance to the daily lives of teachers were made in areas of the survey besides the sections specifically referring to quality and the extrinsic providers determining the types of available opportunities, suggesting that the lack of quality offerings was an inhibiting factor. Terehoff (2002) explained that "teachers need to know that the learning experience will provide them with a sense of growth in their knowledge, understanding, skills, attitude, and interests" (p. 72).

Supporting and Inhibiting Intrinsic Factors

Science teachers as adult learners preferred self-directed, high quality learning opportunities. The forced mandates of administratively determined professional development affected the personal motivations of the interviewed science teachers' engaged participation in district-wide professional development as discussed by Knowles (1970) and increased resistance to required learning if the science teacher did not see the activity as relevant to their needs (Knowles et al., 2011). The fact that survey respondents added "quality" and "relevance" as additional answers as mentioned in the previous paragraph suggested that the quality and relevance of professional development was linked to whether teachers personally chose to participate in a particular activity because of intrinsic factors such as a lack of interest due to poor quality or a great interest due to excellent quality similar to the findings of Schibeci and Hickey (2004). As Guskey (2002) stated in his paraphrasing of Fullan and Miles (1992),

> What attracts teachers to professional development, therefore, is their belief that it will expand their knowledge and skills, contribute to their growth and enhance their effectiveness with students. But teachers also tend to be quite pragmatic. What they hope to gain through professional development are specific, concrete, and practical ideas that directly relate to day to day operation of their classrooms (p. 382).

The science teachers involved in this study were no exception to this statement. The interviewed science teachers found self-selected, off-site opportunities much more relevant, exciting, and engaging even when they invested personal time to research suitable activities and to travel to the offered location, as well as used their own funds to pay for their participation and traveling costs. Science teachers also utilized high levels of informal professional development to update their scientific knowledge which corresponds to Lohman and Woolf's (2001) study on the use of self-initiated, informal activities to learn new things. The lack of choice and the lack of relevant activities available for district-wide events negatively described as "required", "mandated", and "not a choice" by the interviewed science teachers was frustrating for those who really just wanted something that they could use in their own science classrooms with their students.

Some personal factors mostly had a positive influence to support the participation of science teachers in professional development opportunities. Science teachers had a desire to remain up-to-date in their science knowledge which corresponded to the description of people with the NT temperament of the Myers-Briggs Type Indicator who are curious and knowledge-seeking (Tieger and Barron-Tieger, 1995). In turn, as expressed in the qualitative interviews, the cutting-edge science topics were more likely to engage student interest which encouraged the science teachers to gain new scientific knowledge and skills to practice with their own students as suggested by Loucks-Horsley et al. (2010). Personal motivators such as a dedication to teaching and a desire to help students by focusing on their needs were also evident in the quantitative and qualitative data. This supports Guskey's (2002) finding that "although teachers are generally required to take part in professional development by certification or contractual agreements, most report that they engage in these activities because they want to become better teachers" (p. 382).

Science teachers had a much broader range of negatively-focused intrinsic factors that would inhibit their participation in professional development. Interestingly, no science teachers selected lack of confidence as a personal inhibitor. However, the stress of a heavy workload exacerbated by large class sizes and multiple teaching assignments, as well as non-teaching duties inhibited the Minnesota science teachers' participation. High levels of stress as inhibitors support the research of Higgins (2006), Kwakman (2003), Lohman (2000, 2006) Schibeci and Hickey(2004), Scribner (1999) and Wan and Lam (2010). In addition, trying to balance the heavy workload with family obligations also inhibited the participation of the Minnesota science teachers as was found by Schibeci and Hickey (2004), as well as Wan and Lam (2010). Interviewed science teachers who were anxious about changes in teaching assignments, student behaviors, or school climate issues lacked the motivation to concentrate on professional growth which connects to the research of Knight (2000) and Scribner (1999). Overall, the mental and physical tasks involved in teaching, as well as the constant changes happening in school districts were detrimental to science teacher participation.

Supporting and Inhibiting Extrinsic Factors

Resources.

I wish I would have realized
In the days of schoolyard strife,
How precious time was
Before it sprang legs and ran away with my life.

This poem, written by the researcher during a college creative writing course illustrates one of the main findings of this research study: Time seems to be the most precious resource in the personal and professional lives of Minnesota science teachers. In a related survey of teachers, Mertler (2003) performed a follow-up survey asking about their low response rate to the initial survey and found that almost half of the teachers reported that they either didn't want to take the time or they just felt that they didn't have enough available time to take the survey with all of their other teaching duties. For this study, the availability of time was a great supporting resource-related, extrinsic factor for professional development participation and, conversely, the lack of available time also hampered professional development participation which associates with the finding of many researchers including Scribner (1999) and Wan and Lam (2010). Time to find relevant science professional development, time to prepare for substitute teachers and family obligations during your absence, time to travel to off-site workshops, time to participate, and finally, time to reflect to be able to implement and integrate the new information into the classroom curriculum were all time-related factors mentioned as inhibitors by both the quantitative and qualitative participants. Time away from classroom responsibilities and family commitments were fairly equally considered as promoters and inhibitors depending on the surveyed Minnesota science teachers' individual situations which supports professional development for variety according to Kwakman (2003) and Schibeci and Hickey (2004), as well as the importance of relationships with family and students discussed by Scribner (1999) and Wan and Lam (2010).

In addition to all of the general education topics and relicensure requirements, the interviewed science teachers discussed the time required to remain current in the constant shifts in scientific knowledge. Lohman's (2006) study similarly explained how "teachers are required to teach more content and subjects to classes containing greater numbers of students with emotional, social, and learning problems than in the past" (p. 141) and Loucks-Horsley et al. (2010) specifically supported the need for science-related pedagogical content knowledge and skills (Loucks-Horsley et al., 2010). The interviewed science teachers were typically not provided professional development for science content in their own district and some were actually discouraged from traveling to off-site workshops during the school year because of time, funding, personnel constraints, or personal classroom obligations. However, these teachers still needed to update scientific knowledge and develop new techniques to teach their science classes. Some science teachers were expected to do professional learning on their own time during non-contractual hours and periods of time such as before or after school, through summer workshops, or in informal ways (internet searches, reading, conversations with other teachers, etc.) as discussed by Lohman (2006). Even when attending workshops during the school year or in the summer, the interviewed science teachers expressed concern that reflection time and action planning for incorporating and implementing the new information or skills was not included as part of the professional development opportunity or upon the science teachers' return from an off-site activity. Time for reflection is an essential aspect of professional development since "it is simply not enough to develop a new program, however well-designed, if the process of implementation does not provide an opportunity to explore the new ways of thinking, seeing, and believing that affect what we do and how we do it" (Osterman & Kottkamp, 2004, p. x).

The availability of funding and the lack of available funding presented similar supportive and inhibitory effects on the participation of science teachers in professional development, but at a slightly lower level than the resource of time. Costs for substitute teachers that would allow the science teachers to be out of their classrooms for professional development opportunities were supportive if the costs were covered by the school district and inhibitive if the science teacher needed to pay the substitute teacher salary. Similarly, if travel expenses or registration fees were covered by the school district, science teacher participation was supported, but was hindered if those costs were paid by the teachers' personal finances, which in turn, could affect the family relationships due to the financial strain of participation costs supporting the research of Schibeci and Hickey (2004), and Wan and Lam (2010). Scribner (1999) suggested that monetary incentives such as stipends and other remunerations were important supporters, but, for this research study, those factors were not considered as highly supportive as the professional development costs being covered by the school district. Free opportunities available through grants, as well as informal online activities were also utilized by the Minnesota science teachers.

Other resource-related factors such as non-monetary rewards and the distance associated with the location of professional development opportunities did not play as much of a role in the science teachers' participation as time and money. The interviewed science teachers from rural areas discussed traveling distance as a difficulty because, in order to participate in science professional development, they had to travel to larger cities or regional centers. Proximity to colleagues and to technology resources were mentioned as inhibitors for informal opportunities within the school district which upholds the findings of Lohman (2000, 2006). Non-monetary rewards were not a large incentive as a supporting extrinsic factor and the lack of such rewards was not selected at all as inhibitive, even when free materials or college credit were available, as was suggested by Schibeci and Hickey (2004) and Wan and Lam (2010).

Relationships.

The level of support available from relationships with teacher colleagues and school administrators are influential factors for the professional development of science teachers. Supportive relationships from administrators and colleagues were key to successful professional development programs, especially in the light of waning resources, which supports findings by Schibeci and Hickey (2004), Scribner (1999) and Wan and Lam (2010). In addition, Lieberman (1995) suggested that our definition of professional development should be expanded to include those learning opportunities from and with teacher colleagues, but collegial interactions such as classrooms observations in science or other content areas occurred in local schools for less than half of the survey respondents. At the opposite end, the lack of support from administrators and colleagues led to aspects of a toxic learning environment for one interviewed science teacher resulting in a lack of personal motivation to pursue professional learning opportunities which corresponds to Knight's (2000) research. Though interpersonal conflicts with colleagues were prohibitive for Knight's (2000) interviewees, such conflicts were not great inhibiting factors for the Minnesota science teachers. However, about half of the survey respondents reported that administrators retained most of the decision-making powers regarding the scheduling and opportunities for professional development opportunities which agrees with the findings of several researchers including Meister (2010) and Scribner (1999). If informal learning approaches were used, the interviewed science teachers usually performed these actions outside of the school day and in isolation, which corresponds to Lohman's (2006) study where informal learning was restricted by proximity to colleagues, as well as access to technology and resources such as time and money (if substitute teachers were utilized).

Relationships with family members were also prominent factors in determining the participation of the science teachers in professional development. Wan and Lam (2010) suggested that the family factor may be understated as an inhibitor in previous studies, but the results of this study, that having the support of family members to participate was a very important factor for many science teachers, coincide with their findings. However, participation by the Minnesota science teachers also meant time spent away from the family and affected the orchestration of family schedules which was also reported by Schibeci and Hickey (2004), Scribner (1999) and Wan and Lam (2010).

Interactions Between and Among the Intrinsic and Extrinsic Factors

Several researchers including Higgins (2006), Kwakman (2003), Schibeci and Hickey (2004), and Scribner (1999), as well as Wan and Lam (2010) discussed the levels of personal (intrinsic) and environmental (extrinsic) factors and their areas of overlap. Schibeci and Hickey (2004) suggested that personal factors and environmental factors intersect and ultimately affect the choices that teachers make regarding their participation in professional development opportunities. The analysis of the quantitative and qualitative results for this study re-emphasized that concept. Intrinsic and extrinsic factors are often linked and difficult to fully separate. Interactions may occur between and even among multiple levels of intrinsic (personal) and extrinsic (resources and relationships) factors. Combinations of factors were involved when science teachers first made the decision to pursue professional development. As the interviewed science teachers described the process used, resources were considered. They appeared to ask themselves: Do I have the time to research and find a high quality professional development activity? Do I have the time and money to attend? Relationships were also considered by these questions: Will my administrator provide the resources (time and money) and support to attend? Will support and reflection continue after the professional development event? Will my participation affect my family? Finally, personal factors also played a role in the decision: Will this professional development experience be of high quality? Will my effort to prepare for participation (substitute teacher plans, travel reservations, etc.) be worthwhile? How will my absence affect my students? This last question was actually very influential for the interviewed science teachers as the relationships with students and their learning often overshadowed the science teachers' own learning needs and desires, similar to the moral obligations to help students described by Schibeci and Hickey (2004) as well as Wan and Lam (2010). The interviewed science teachers explained why they were reluctant to be gone from the classroom, even for effective and relevant professional development, because of the loss of instructional time for students, in addition to the time and effort required to prepare for their absence that was mentioned by the survey respondents and supported by the work of Lohman (2000), Schibeci and Hickey (2004), and Wan and Lam (2010).

Besides the considerations above and connections mentioned previously in individual categories, many other associations exist. The access to resources such as time and money often affected how science teachers personally chose to spend their time including interactions with family or friends as was also discussed in the research of

Schibeci and Hickey (2004) and Wan and Lam (2010). When the interviewed science teachers participated in self-selected, off-site workshops, they often paid for the expenses themselves which gave them an extra incentive to choose high quality, relevant, and engaging activities. Collegial support was personally determined by some science teachers surrounding themselves with helpful people whereas, for others, the support structure was externally constructed by the administrators and overlapped with the science teachers' lack of decision-making powers as also discussed in Higgins (2006), Knight (2000) and Scribner (1999). In addition, collegial relationships were personally motivating if supportive as found by Kwakman (2003), Meister (2010), and Schibeci and Hickey (2004), but isolation and conflicts, though not common in the survey data, led to further frustration for at least one interviewed science teacher similar to Knight's (2000) findings. Even in isolation, informal professional development was often utilized by the interviewed science teachers to access new knowledge and satisfy personal interests quickly (rather than attending workshops), but designated time was typically not allocated by school administrators for such activities just as Lohman (2000) discussed the loss of non-teaching time as an inhibitor to informal learning. Thus, the personal intrinsic and extrinsic factors relating to resources and relationships (See Figure 2) affecting the professional development participation of science teachers were multifaceted and intersecting in many aspects.

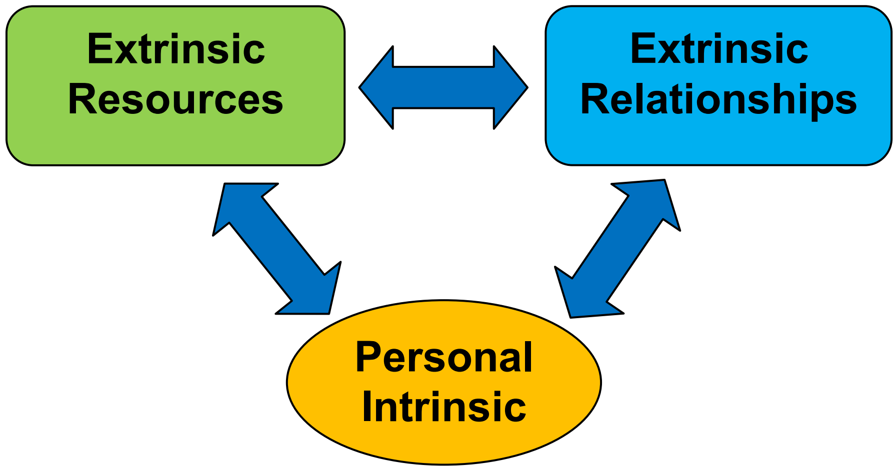

Figure 2. Interactions Between and Among Intrinsic and Extrinsic Factors

General implications

As a consequence of this study, several overall implications may be derived from the results. More high quality professional development needs to be available to all teachers that include practical, relevant, and differentiated experiences (Wei et al., 2009). Secondly, more science-related professional development should be provided within local school districts. Specific strategies will be discussed further in the "Implications for professional development providers" section including approaches more applicable for rural science teachers. Thirdly, resources including time, money, space, technology, equipment, and personnel should be used more creatively and efficiently for professional development purposes. Finally, more and better communication needs to occur surrounding what constitutes high quality professional development and the details about where and when to find exactly what teachers need or desire to complement the demands of their students and teaching situation.

Implications for science teachers

The results of this study indicated that supportive collegial relationships were influential factors for the professional development participation of science teachers. Science teacher colleagues could be encouraged to pursue professional development opportunities that enable them to fill new leadership roles and promote collaborative efforts with teacher colleagues and school administrators (Loucks-Horsley et al., 2010). Science teachers embracing teacher leadership roles could advocate for high quality professional development, especially in science content and science pedagogical knowledge. High quality professional development for science teachers should occur within the district and include reflection time to incorporate and make an action plan for implementation. Teacher leaders would also consult with peers and school administrators on the best ways to reconfigure resources such as time, money, space, and personnel to provide high quality professional development to everyone, as well as work toward a complete professional learning community. For example, science teachers who are applying informal strategies in their professional learning should be granted a fair amount of time (or other compensation) to do so. Finally, teacher leaders would promote the idea of showcasing local district specialists as professional development providers since internal staff members would be more knowledgeable about the needs of that specific district than an outside expert.

Implications for school administrators

School administrators are often limited by the constraints of their systems (Elmore, 2008), but they will need to find creative ways to work around those issues in order to provide high quality professional development to all teachers, including the science teachers. School administrators will need to better understand the components of high quality professional development to ensure that opportunities are sustained over time and that activities are provided to improve the content knowledge and skills. In addition, adult learning principles regarding intrinsic motivations should be considered, especially in the areas of informal learning, which were highly utilized, self-determined opportunities by survey respondents and interviewed teachers to supplement workshop findings or to discover current science events to peak student interest.

Results from this study also indicated that supportive relationships with school administrators are important promoting factors for science teacher participation in professional development activities. School administrators can support the participation of science teachers in established learning community groups within their schools by ensuring that provisions are made for discussions and activities surrounding the specialties of science and science education. School administrators need to work with other stakeholder groups such as the science teachers and the policymakers to ensure that the proper resources are allocated or to at least find creative ways to utilize those resources to their utmost potential. School administrators should provide better access, through allocated time and technology resources, to informal learning opportunities to help alleviate teacher stress related to time constraints or to outside family obligations. School administrators need to promote a collaborative, creative learning environment within the school by addressing issues of teacher morale and motivation, as well as teacher competence. Finally, school administrators should stress the *professional* part of development by providing opportunities for science teachers to select their own path of professional learning (including time for informal learning opportunities and individual reflection) and by advocating for local teachers to "teach" their colleagues.

Implications for policymakers

Resources have been shown to be an essential factor for the professional development participation of the Minnesota science teachers involved in this research study. Policymakers control the availability of and access to the resources required by schools which, in turn, affects the opportunities for high quality professional development. Therefore, policymakers first need to ensure that science teacher professional development initiatives have the necessary resources to not only begin a program, but to also be sustained and supported over time. Secondly, the policymakers need to focus on a model of teacher growth and development rather than only deficit models and assess what the actual needs of the science teachers are rather than what the American public perceives as the needs of science teachers. In order to assure present and future participation in high quality professional development initiatives, the principles of adult learning principles should be considered and the design of the professional development strategies should be around the assessed needs of the science teachers. Gregson and Sturko (2007) and Steinke (2012) discussed the increased benefits for teacher participating in professional development when the adult learning principles, including those focused upon intrinsic motivators and self-directed learning, were utilized.

An additional implication for policymakers is regarding the equitable access to and allocation of funding. Many sources of funding are available, but the lack of information about those sources and the actual application to receive such funds are prohibitive. Eisenhower funds which were discontinued over a decade ago were mentioned by more experienced science teachers as an important tool to promote science teacher participation in professional development opportunities, and yet, not all districts applied for that funding. Small districts or districts without dedicated grant-writers did not always apply for those grants because of the time and effort required to apply and evaluate the progress (U. S. General Accounting Office, 1992). Policymakers should ensure that grant-writing opportunities are easily accessible and attainable by all districts, especially districts with limited access to outside professional development activities.

Implications for professional development providers

Professional development providers are usually charged with sessions meant for teachers in wide varieties of content areas and learning needs. If specific sessions are not able to be differentiated for science teachers, certain strategies could be utilized to make general professional development sessions more relevant to the needs of science teachers. These strategies could very easily be incorporated into professional development sessions that include teachers of multiple content areas and discuss topics that are also relevant to general education such as inquiry-based teaching, constructivism, student safety, brain research about learning, and environmental issues with social as well as economic impacts such as water quality, energy usage, and global climate change.

Although professional development providers are presenting pertinent science knowledge and skills, they must also consider the future access to resources of their intended audience. Bravo, a science teacher participating in an interview, explained the necessity for relevant, as well as practical learning experiences:

> We're doing some workshops for the engineering parts of the science standards through the University of Minnesota. They've got people coming in and we had one session. It was great. It was wonderful, but it had all this equipment that we don't have. And they did not have a giveaway program or a program where this equipment was going to be available at a reduced cost. So, we spent all day working with equipment that we weren't ever going to see again. That's not beneficial as far as I can see it. If you're going to come in with some particular equipment, there's got to be a plan for how teachers can actually get that into their classroom (personal communication, January 29, 2013).

In addition, Bravo mentioned the needs of science teachers to better incorporate the scientific contributions of Minnesota Native Americans in a culturally proficient manner suggested by Loucks-Horsley et al. (2010):

> One of the areas in the science standards that we really need help in is the Native American contributions. We went to one and they put out a diagram of a canoe, a model of a canoe and said this is engineering. Native American engineering and that was their example for the workshop. And I was, like, that doesn't cut it for me. You know, not only is it supposed to be Native American, but it is supposed to be Minnesota Native American, so pulling in Native American things from the

west coast with their environmental studies of the otters and stuff, that doesn't fit our standard (personal communication, January 29, 2013).

Professional development providers should also consider the needs of rural science teachers when they are designing the program. Rural teachers especially described the combination of factors such as time, money, and distance that inhibit their participation in science-related professional development. Wilson and Ringstaff (2010) suggested that rural settings provide excellent areas for scientific learning because of the access to natural areas to alleviate travel costs. Other specific suggestions included an intensive, face to face summer institute to establish relationships amongst teachers who would later form learning communities for ongoing collaborative efforts and encouraging science teachers to become teacher leaders assisting with curriculum development (Wilson & Ringstaff, 2010). Although the participants in the Wilson and Ringstaff (2010) study preferred face to face opportunities, online learning communities could be an additional strategy to address the isolation of rural science teachers.

Recommendations for further study

Based on the information received through the data collection methods, the following suggestions for further research were uncovered:

- Relationships between and among factors–The complex interactions between intrinsic and extrinsic factors provide many opportunities for future research relating to the questions listed below.

1. How does the quality of professional development (determined by external sources) correlate with the level of interest and engagement by science teachers in future professional development opportunities?
2. When comparing intrinsic and extrinsic factors, is one set of factors more influential over the other? Can a model be developed that predicts the factors influencing participation?
3. How does addressing the resource issues of time and money affect the personal factors relating to science teacher professional development participation?
4. Why would the positively-focused personal factors be more influential than the negatively-focused personal factors?

- Science-related professional development activities within local school districts- The lack of science professional development available in local school districts, especially during school-based in-services, was mentioned during the qualitative interview process, but such information was not collected through the quantitative survey. The following questions might be of interest:
    1. Does science-related professional development actually occur within local school districts during school-based in-services?
    2. How often does science-related professional development occur within local school districts during school-based in-services?
    3. What format (s) is used for these science-related professional development activities?

4. Which Loucks-Horsley et al. (2010) recommendations are being utilized in designing professional development for science teachers?

- The use of formal and informal professional development–Science teachers participated in both formal and informal professional development, using formal for introductions to new material and informal to perform "on the spot" research about the latest science developments.
    1. How, where, when, and why would one type of professional development be preferred over the other?
    2. Is designated time given for informal professional development activities?
    3. How do school administrators and central office personnel allocate resources for formal and informal professional development activities?
- The needs of rural science teachers compared to urban and suburban teachers.
    1. How are the needs of rural science teachers who teach multiple grade levels and multiple disciplines met through formal professional development opportunities?
    2. How are professional development opportunities and related grants for participation communicated to rural schools?
    3. Can online professional development work towards reducing the isolation of rural science teachers?

Conclusion

In conclusion, the results of this research study show that some aspects of high quality professional development are being offered to experienced, highly qualified secondary science teachers in Minnesota. Efforts are being made to include more aspects of job-embedded learning in the daily practices of teachers and have the opportunities be driven by teacher needs. Science teachers participated in many types of formal and informal opportunities to improve their professional knowledge and skills. However, the opportunities for improving skills in science and science education are not as available within local school districts as those for general education topics such as differentiated instruction or technology integration. Resource-related extrinsic factors such as time and money are very influential elements in determining the participation of a science teacher in professional development opportunities, but those factors greatly interact with personal intrinsic factors which also affect the extrinsic relationships. The personal intrinsic factors of science teachers include great desires to gain more knowledge and skills in science which, ultimately, also helps their students. In addition, supportive relationships with school administrators, teacher colleagues, and family members are sustaining forces that promote professional development participation even when sufficient resources are not available. In 1995, Miles wrote the Foreword to Guskey and Huberman's book about new paradigms in professional development. Although his statement may seem harsh, the reality of this statement could still be considered applicable to this research study almost two decades later:

> A good deal of what passes for "professional development" in schools is a joke-one that we'd laugh at if we weren't trying to keep from crying. It's everything that a learning environment shouldn't be; radically under resourced; brief, not sustained; designed for "one size fits all"; imposed rather than owned; lacking any

> intellectual coherence; treated as a special add-on event rather than as a part of a natural process; and trapped in the constraints of the bureaucratic system we have to call "school". In short, it's pedagogically naïve, a demeaning exercise that often leaves its participants more cynical and no more knowledgeable, skilled, or committed than before. And all this is accompanied by overblown rhetoric about "the challenge of change", "self-renewal", and "lifelong learning". Not all professional development is like that.

As Echo, an interviewed science teacher mentioned, "Good science professional development is available. I think it just comes down to personal goals and taking the time to search for it and attend it" (personal communication, February 22, 2013) However, for the most part, our Minnesota schools are still operating under a deficit model of professional development where teachers have little control over their professional development choices and opportunities, especially within their own districts. Although the purpose for improving the morale or refreshing the teachers' outlook for teaching and learning was not mentioned by participants in this study, our schools can hopefully still move toward models of teacher growth and self-reflection, especially in light of the new teacher evaluation and development requirements being implemented in Minnesota statutes. The researcher greatly hopes that Elmore's (2008) insight will eventually ring true that "schools should become places dedicated to adult and student learning" (p. 223) to have a positive effect on the scientific literacy of all of our country's learners.

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Appendix A

Science Teacher Professional Development Survey

Q1. In the past 12 months, have you participated in any type of professional development with the following characteristics? (Please select one answer per line.)

Question	Yes	No
Actively engaged in learning during daily teaching practices	❍	❍
Integrated into the school day	❍	❍
Related to district goals	❍	❍
Driven by teacher needs	❍	❍
Improved depth of content knowledge and/or skills for science	❍	❍
Broadened content knowledge and/or skills in other science disciplines	❍	❍
Improved knowledge specifically on how to teach science content	❍	❍

Q2. In the past 12 months, have you participated in any type of professional development that has been sustained over time through support beyond the initial learning opportunity?

❍ Yes
❍ No

Answer if "In the past 12 months, have you participated in any type of professional development that has been sustained over time through support beyond the initial learning opportunity?" Yes is selected.

Q3. Over what time period was the professional development support continued?

❍ Direct support ended several days after the initial learning opportunity.
❍ Direct support ended several weeks after the initial learning opportunity.
❍ Direct support ended several months after the initial learning opportunity.

Q4. In the past 12 months, have you participated in any of the following activities related to general education and/or teaching? (Please select one answer per line.)

Question	Yes	No
Formal college or university course for credit	❍	❍
Research conferences or seminars	❍	❍
Off-site workshops	❍	❍
School-based inservices	❍	❍
Observation visits to other schools	❍	❍
Observations of local district colleagues	❍	❍
Mentoring and / or peer coaching	❍	❍
Online courses	❍	❍

Q5. In the past 12 months, how many hours did you spend in total in these activities related to general education and / or teaching?

❍ 8 hours or less
❍ 9 - 16 hours
❍ 17-32 hours
❍ 33 or more hours

Q6. In the past 12 months, have you participated in any of the following activities related to science or the teaching of science? (Please select one answer per line.)

Question	Yes	No
Formal college or university science course	❍	❍
Formal college or university course in the teaching of science	❍	❍
Scientific research conferences or seminars	❍	❍
Off-site workshops on science teaching.	❍	❍
Observations of other teachers teaching science	❍	❍
Mentoring and/or peer coaching in science teaching	❍	❍
Online professional development for science teaching	❍	❍
Study groups with local colleagues to discuss science teaching issues	❍	❍
National or state science teacher association meeting.	❍	❍

Q7. In the past 12 months, how many hours did you spend in total on these activities related to science and / or the teaching of science?

❍ 8 hours or less
❍ 9-16 hours
❍ 17-32 hours
❍ 33 or more hours

Q8. In the past 12 months, did you participate in any of the following informal professional development activities when you needed to learn something new for your teaching assignment? As you respond please consider activities related to general education, as well as science teaching. (Please select one answer per line.)

Question	Yes	No
Reading professional literature (e.g. journals, thesis papers, etc.)	❍	❍
Talking informally with colleagues about how to improve your teaching	❍	❍
Sharing materials and resources with others	❍	❍
Networking with teachers from other schools	❍	❍
Researching individually or in collaboration with others	❍	❍
Searching the Internet	❍	❍
Attempting new ideas through trial and error	❍	❍
Reflecting on your actions	❍	❍
Other activities? Please specify:	❍	❍

Q9. In the past 12 months, how many hours did you spend in total on these informal activities related to general education and / or teaching?

❍ 8 hours or less
❍ 9 - 16 hours
❍ 17-32 hours
❍ 33 or more hours

Q10. In the past 12 months, how many hours did you spend in total on these informal activities related to science and / or the teaching of science?

❍ 8 hours or less
❍ 9-16 hours
❍ 17-32 hours
❍ 33 or more hours

Q11. Which resource-related item below most strongly supports your participation in any type of professional development?

- ❍ Available time
- ❍ Available money
- ❍ Non-monetary rewards
- ❍ Distance to professional development opportunities
- ❍ Other ____________________

Answer if "Which resource-related item below most strongly supports your participation in any type of professional development?" Available time is selected.

Q12. Which 3 factors related to time most strongly support your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the most supportive, 2 = the second most supportive, and 3 = the third most supportive.

______ Release time available for participation
______ Professional development time available on weekends
______ Professional development time available after school
______ Less travel time necessary for local learning opportunities
______ Time away from school and / or classroom responsibilities
______ Time away from family responsibilities
______ Other? Please specify:

Answer if "Which resource-related item below most strongly supports your participation in any type of professional development?" Available money is selected.

Q13. Which 3 factors related to money most strongly support your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the most supportive, 2 = the second most supportive, and 3 = the third most supportive.

______ School or district paid registration fees
______ School or district paid substitute teacher salaries
______ One-time salary supplements from school district for participation
______ Contractual salary increases related to credit completion
______ Stipends from professional development providers
______ Scholarships from post-secondary institutions
______ Paid college tuition for course credits
______ Reduced entry fees for returning participation
______ Travel and / or lodging reimbursements
______ Available funds to purchase materials to implement new strategies
______ Other? Please specify:

Answer if "Which resource-related item below most strongly supports your participation in any type of professional development?" Non-monetary rewards is selected.

Q14. Which 3 factors related to non-monetary rewards most strongly support your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the most supportive, 2 = the second most supportive, and 3 = the third most supportive.

_______ Free non-curricular books
_______ Free curriculum and / or classroom supplies
_______ Opportunities for travel
_______ Opportunities to meet new people
_______ Opportunities to fulfill license requirements
_______ Opportunities for job promotions
_______ Opportunities for resume or curriculum vitae additions
_______ Opportunities for leadership roles
_______ Administrative and / or community recognition
_______ Other? Please specify:

Answer if "Which resource-related item below most strongly supports your participation in any type of professional development?" Accessible locations is selected.

Q15. Which 3 factors related to location most strongly support your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the most supportive, 2 = the second most supportive, and 3 = the third most supportive.

_______ Reasonable distance to off-site locations
_______ Proximity to district colleagues
_______ Proximity to school department offices
_______ Proximity to libraries
_______ Proximity to community resources
_______ Proximity to technology resources (e.g. computers, computer labs)
_______ Other? Please specify:

Q16. Which resource-related item below most strongly inhibits your participation in any type of professional development?

❍ Lack of available time
❍ Lack of available money
❍ Lack of non-monetary rewards
❍ Distance to professional development opportunities
❍ Other? Please specify: ____________________

Answer if "Which resource-related item below most strongly inhibits your participation in any type of professional development?" Lack of available time is selected.

Q17. Which 3 factors related to time most strongly inhibit your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the strongest inhibitor, 2 = the second strongest, and 3 = the third strongest.

_______ Time required to travel to off-site locations
_______ Time required to prepare for substitute teachers
_______ Time required to manage large class sizes
_______ Time required to create accommodations for students
_______ Time required for school-related, non-teaching duties
_______ Time spent working at another job
_______ Time spent away from family and / or friends
_______ Lost recreational time
_______ Other? Please specify:

Answer if "Which resource-related item below most strongly inhibits your participation in any type of professional development?" Lack of available money is selected.

Q18. Which 3 factors related to money most strongly inhibit your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the strongest inhibitor, 2 = the second strongest, and 3 = the third strongest.

_______ Lack of district funding for professional development costs
_______ Lack of district funding for substitute teacher salaries
_______ Lack of funding to purchase materials to implement new strategies
_______ Personal financial costs for registration fees
_______ Personal financial costs for travel and / or lodging expenses
_______ Personal financial costs for substitute teacher salaries
_______ Personal financial costs for childcare
_______ Other? Please specify:

Answer if "Which resource-related item below most strongly inhibits your participation in any type of professional development?" Lack of non-monetary rewards is selected.

Q19. Which 3 factors related to non-monetary rewards most strongly inhibit your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the strongest inhibitor, 2 = the second strongest, and 3 = the third strongest.
_______ Lack of free non-curricular books
_______ Lack of free curriculum and / or materials
_______ Lack of variety in professional development opportunities
_______ Lack of opportunities to fulfill license requirements
_______ Lack of opportunities for job promotion
_______ Lack of opportunities for resume or curriculum vitae additions
_______ Lack of opportunities for leadership roles within district
_______ Lack of administrative and / or community recognition
_______ Other? Please specify:

Answer if "Which resource-related item below most strongly inhibits your participation in any type of professional development?" Distance to professional development opportunities is selected.

Q20. Which 3 factors related to location most strongly inhibit your participation in formal or informal professional development? Please rank your top 3 choices with 1 = the strongest inhibitor, 2 = the second strongest, and 3 = the third strongest.
_______ Off-site locations are not a reasonable distance from home or work
_______ Lack of proximity to district colleagues
_______ Lack of proximity to school department offices
_______ Lack of proximity to libraries
_______ Lack of proximity to community resources
_______ Lack of proximity to technology resources
_______ Other? Please specify:

Q21. Which of the following personal characteristics most strongly influences your participation in any type of professional development?

- ❍ Desire to learn more
- ❍ Desire to help students
- ❍ Social personality
- ❍ Self-efficacy
- ❍ Self-initiative
- ❍ Enthusiasm
- ❍ Youthfulness
- ❍ Other ____________________

Q22. Which of the following items most strongly inhibits your participation in any type of professional development?

- ❍ Stress of heavy workload
- ❍ Stress of family and / or outside obligations
- ❍ Mental and / or physical exhaustion
- ❍ Lack of information about professional development opportunities
- ❍ Changes in teaching assignments (larger classes, new grade level, different subject)
- ❍ School policies do not seem to support changes in classroom activities
- ❍ Professional development learning does not seem to be supported by administrators
- ❍ Student behavior does not seem to change
- ❍ Lack of self-confidence
- ❍ Other ____________________

Q23. In considering relationships with other teachers in your school district, is your participation in professional development supported in the following ways? (Please select one answer per line.)

Question	Yes	No
Colleagues offer recommendations for professional development	❍	❍
Colleagues offer support or peer coaching	❍	❍
Colleagues provide subtle pressure to participate	❍	❍
Isolation from colleagues promotes off-site participation	❍	❍
Interpersonal conflicts with colleagues promote self-initiated learning	❍	❍
Other? Please specify:	❍	❍

Q24. In considering relationships with other teachers in your school district, is your participation in professional development inhibited in the following ways? (Please select one answer per line.)

Question	Yes	No
Interpersonal conflicts with colleagues inhibit supportive relationships.	❍	❍
Colleagues provide too much pressure to participate.	❍	❍
Isolation from colleagues inhibits relationships.	❍	❍
Other? Please specify:	❍	❍

Q25. In considering relationships with school administrators, is your participation in professional development supported in the following ways? (Please select one answer per line.)

Question	Yes	No
School-based professional development is related to school goals.	❍	❍
Administrators provide access to effective professional development.	❍	❍
Shared decision-making powers are used for professional development issues.	❍	❍
Administrators provide flexible scheduling for professional development.	❍	❍
Other? Please specify:	❍	❍

Q26. In considering relationships with school administrators, is your participation in professional development inhibited in the following ways? (Please select one answer per line.)

Question	Yes	No
Compulsory, school-based professional development is not related to district goals.	❍	❍
Access to effective professional development resources is not provided.	❍	❍
The decision-making powers of teachers for professional development are limited.	❍	❍
Flexible scheduling for professional development opportunities is not provided.	❍	❍
Other? Please specify:	❍	❍

Q27. In considering relationships with family members, is your participation in professional development supported in the following ways? (Please select one answer per line.)

Question	Yes	No
Family members encourage personal growth.	❍	❍
Family members contribute to balancing work and family time.	❍	❍
Professional development provides opportunities for variety outside of family life.	❍	❍
Other? Please specify:	❍	❍

Q28. In considering relationships with family members, is your participation in professional development inhibited in the following ways? (Please select one answer per line.)

Question	Yes	No
Participation causes disruptions to home schedules.	❍	❍
Participation causes difficulties with childcare arrangements.	❍	❍
Participation causes undue strains on family finances.	❍	❍
Participation causes difficulties balancing work and personal time.	❍	❍
Participation means too much time is spent away from family events.	❍	❍
Other? Please specify:	❍	❍

Q29. What are the subject(s) for each of your degrees? (Please select all that apply.)

Subject	Bachelors	Masters	Doctorate
Biology/Life Science	❑	❑	❑
Chemistry	❑	❑	❑
Earth/Space Science	❑	❑	❑
Physics	❑	❑	❑
Other science, please specify:	❑	❑	❑
Science Education (any science discipline)	❑	❑	❑
Mathematics/Mathematics Education	❑	❑	❑
Elementary Education	❑	❑	❑
Other Education (e.g., History Education, Special Education)	❑	❑	❑
Other? Please specify:	❑	❑	❑

Q30. Which grade level(s) do you currently teach? (Please select all that apply, including courses with students at multiple grade levels.)

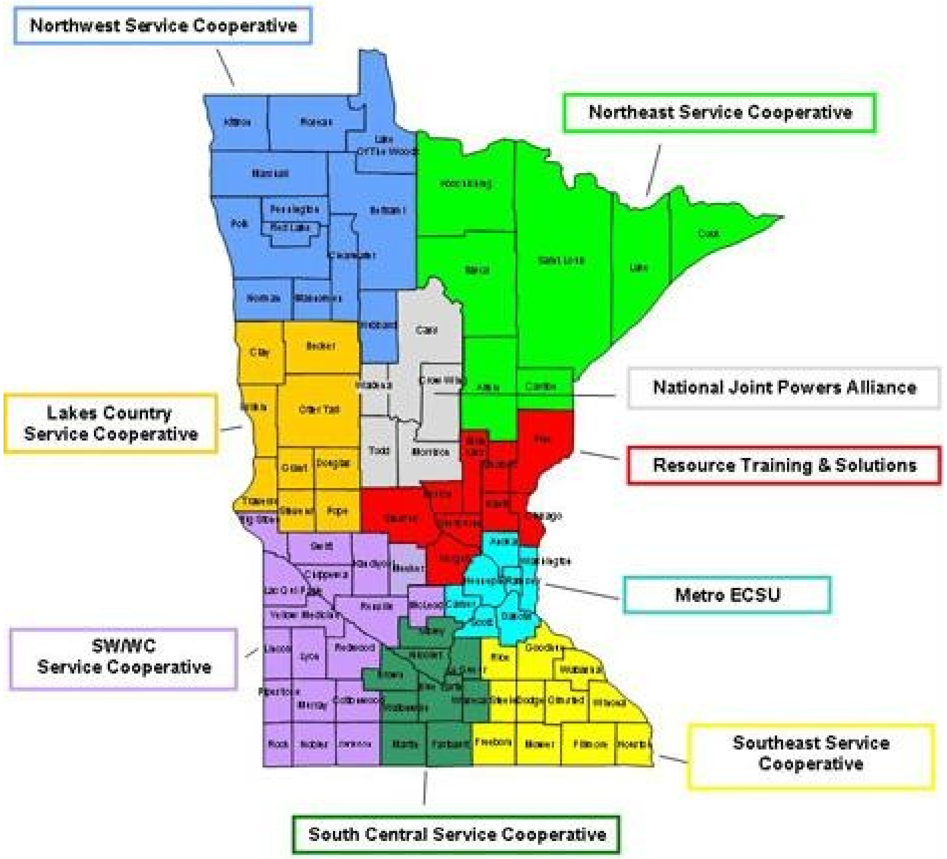
- ❑ Elementary, Kindergarten - 4th grade
- ❑ 5th grade
- ❑ 6th grade
- ❑ 7th grade
- ❑ 8th grade
- ❑ 9th grade
- ❑ 10th grade
- ❑ 11th grade
- ❑ 12th grade
- ❑ Other? Please specify: ____________________

Q31. Which science course(s) do you currently teach? (Please select all that apply.)

- ❑ Biology
- ❑ Chemistry
- ❑ Earth and Space Science
- ❑ Environmental Science
- ❑ General Science
- ❑ Life Science
- ❑ Physical Science
- ❑ Physics
- ❑ Other? Please specify:

Q32. How many years have you taught at the K-12 level prior to this school year?

- ❍ 0 - 4 years
- ❍ 5 - 10 years
- ❍ 11- 15 years
- ❍ 16 - 20 years
- ❍ 21 - 25 years
- ❍ 26 - 30 years
- ❍ 31 - 35 years
- ❍ Over 35 years



Q33. Which Minnesota Service Cooperative Educational District depicted above includes your school's location?

- ❍ Lakes Country
- ❍ Metro
- ❍ National Joint Powers Alliance
- ❍ Northeast
- ❍ Northwest
- ❍ Resource Training and Solutions
- ❍ South Central
- ❍ Southeast
- ❍ Southwest / West Central

Q34. How would you classify the location of your school?
❍ Rural
❍ Suburban and / or Larger City
❍ Urban

Q35. Please indicate your sex:
❍ Male
❍ Female

Q36. Approximately 5 teachers will be asked to participate in follow-up interviews to enhance the understanding of survey responses. Would you be willing to participate in a follow-up interview that maintains your confidentiality, occurs at a location convenient to you, and would last approximately one hour?
❍ Yes
❍ No

Answer if "Would you be willing to participate in a follow-up interview that maintains your confidentiality, occurs at a location convenient to you, and would last approximately one hour?" Yes is selected.

Q37. Please list your preferred form of contact information and a convenient time to contact you. For example: My home telephone number, 123-456-7890 after 6:30 p.m., Monday – Friday.
❑ Email ____________________
❑ Home telephone ____________________
❑ Work telephone ____________________

Q38. Additional comments?

Appendix B

Science Teacher Interview Questions

1. What science discipline(s) do you typically teach?
2. What grade level(s) do you teach?
3. How long have you been teaching?
4. How many years have you been teaching in your current district?
5. How would you define professional development?
6. What do you believe is the purpose of professional development?
7. In what types of professional development opportunities have you engaged?
8. What professional development opportunities are available to you as a science teacher?
9. How would you describe your experience with professional development activities within your own district?
10. How would you describe your experience with professional development activities occurring outside of your school district?
11. What types of professional learning experiences have you personally sought on your own?
12. What are some aspects of your job in general as a teacher that require you to develop your professional knowledge and / or skills?
    a. What professional knowledge did you need to develop?
    b. What professional skills did you need to develop?
    c. How did you acquire this knowledge and these skills?

13. What are some aspects of your job as a science teacher that require you to develop your professional knowledge and / or skills in science-related fields?

    a. What scientific knowledge did you need to develop?

    b. What science-related skills did you need to develop?

    c. How did you acquire this knowledge and these skills?

14. What influences your decision to use one activity versus another to acquire new knowledge and/or skills?

15. What personal attributes have helped or hindered your learning efforts?

16. Are there any other things that may help or hinder your learning efforts?