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Examining Adolescence Science And Mathematics Teachers' Views Of The Characteristics Of Effective Professional Development: A Q-methodological Study

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Abstract

The design and implementation of secondary teacher professional development (PD) has been a focus of researchers for decades. Often viewed as the way to increase the quality of teaching and to improve student achievement, billions of dollars are invested in PD within the United Stated every year. As such, researchers continue to seek new avenues to understand and to improve the benefits of PD.

An area of inquiry that has drawn specific interest amongst some investigators are the characteristics of effective PD. Numerous studies purport the need for these characteristics to be included in the design of PD. Yet, teachers' perspectives regarding these characteristics are lacking from the many studies that exist. Additionally, the growing list of characteristics in the research literature poses a challenge for PD facilitators who are trying to design professional learning activities as they cannot necessarily incorporate all characteristics. As such, this study employed the use of Q methodology to examine teachers' perceptions of the characteristics of effective professional development PD to identify those characteristics teachers identify as most important to their professional growth.

National standards emphasize the importance of integrated STEM instruction at the adolescence education level. The practices called out in the standards are in many ways new and novel for teachers. As such, contemporary research has emphasized the importance of PD for STEM teachers. Hence, this study focused on science and mathematics teachers in grades 7-12.

Three research questions were explored for this study: (i) What do science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on the characteristics of effective PD? (ii) What connections exist between the characteristics of effective PD science and mathematics teachers view as being important to their learning and the core adult learning

principles? (iii) To what extant can the continually growing list of characteristics of effective PD be narrowed down to specific factors that can be considered when designing professional learning activities for science and mathematics teachers. To better interpret the teachers' views of these characteristics, andragogy and its six core adult learning principles, as researched by Malcolm Knowles et al. (2015), was used as the theoretical framework for this study.

Participants in this study consisted of science and mathematics *master* teachers (n=30 and n=13, respectively) that teach in grades 6-12. Teachers were presented with 44 statements (Q sample) and asked to force-rank these statements onto a Q sort distribution grid from +5 to -5. Participants also completed a supplemental questionnaire that gathered information regarding the choices teachers made in the sorting process and collected demographic information from the teachers. As Q methodology is a mixed-methods approach to study subjectivity, factors were extracted from the correlated sorts of participants and those factors were interpreted using the supplemental information collected from the teachers.

Results revealed there were specific characteristics teachers valued more for their growth over others (e.g., engaging in active learning; time to collaborate with peers). Based on the factor extraction and interpretation that was conducted, five factors were identified for the science teachers and three factors were identified for the mathematics teachers that participated. While similarities did exist between the two groups, some differences were encountered as well.

Findings from this study suggest that there may be specific factors that PD facilitators could consider in the design and facilitation of PD. There were several connections identified between what was important for teachers' growth and adult learning theory. Researchers may benefit from the instrument in this study when focusing on the professional needs of teachers in other disciplines.

EXAMINING ADOLESCENCE SCIENCE AND MATHEMATICS TEACHERS' VIEWS OF THE CHARACTERISTICS OF EFFECTIVE PROFESSIONAL DEVELOPMENT: A Q-METHODOLOGICAL STUDY

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Having gone through this process, I feel prepared to take off the training wheels and become a researcher in my own right (and in a way, that has already begun). I know I will continue to have amazing support system as I continue to learn and grow.

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Chapter 1: Introduction

1.1 Thesis Overview

This study was undertaken because of my commitment to facilitating high-quality professional learning experiences for science, technology, engineering, and mathematics (STEM) teachers. Over the past seven years I have been the assistant director of a statewide program in New York State (NYS) that is aimed at improving the content and pedagogical knowledge of K-12 STEM educators. The expectation is that by providing extensive professional learning opportunities for a select group of high-achieving "master teachers", they will use the additional training as the foundation for mentoring other STEM educators, either in their same school, within the same district, or perhaps beyond their district boundaries. The ultimate goal of providing these learning experiences for teachers, then, is improving the quality of STEM education for all students in accordance with the educational and professional development (PD) efforts in New York State. In 2012, the New York State Education Department (NYSED) released PD standards. In part, these standards are grounded in research that teacher quality predicts student achievement, and therefore teachers must be afforded "ongoing, high quality professional development to sustain and enhance their practice" (NYSED, 2012, p. 1).

In order to effectively facilitate professional learning activities for teachers, I believe it is my responsibility to learn as much as I can in order to provide opportunities that are beneficial to the practice of the participants and meet their respective needs. Through my early explorations in preparing to create professional learning opportunities, I came across a passage in the book *Power of Protocols: An Educator's Guide to Better Practice* (McDonald et al., 2013) that struck a chord within me and has guided my work as a practitioner and researcher. The authors of this book stated "To say that we ought to educate ourselves, therefore, means that PD activities for

educators that are designed and conducted without benefit of inside perspectives are not worth the time and money they cost" (McDonald et al., 2013, pp. 2). This quote suggests that teachers should be directly involved in the creation and implementation of professional learning opportunities. Certainly, there are examples in the research literature that suggest including teachers' voices in the change process brought about by PD (Dadds, 2014; Fetters et al., 2002). Even more important to my work is the idea that when teachers' perspectives are not brought to the table for inclusion, then such professional learning is not worthwhile. This one quote, then, has ignited a spark in me to learn all I can about the history of PD and how to become a better practitioner when it comes to creating and leading professional learning for teachers.

1.2 Statement of the Problem

The purpose of this research study was to examine teachers' perceptions of the characteristics of effective PD, as defined within education research literature. Researchers have consistently sought to identify these "features", "elements", or "characteristics" of effective PD (Darling-Hammond et al., 2017; Guskey, 2003; Main et al., 2015), leading to numerous and continually evolving lists that have been created mainly from posttests (summative evaluations) collected from teachers at the completion of a particular PD opportunity (Arbaugh, 2015; Ramlo, 2012).

The growing list of characteristics would seem to make it challenging to incorporate all of the many characteristics of effective PD into the design of a professional learning activity. Further, evidence is lacking for many of these characteristics as to whether incorporating them into PD design actually leads to better teaching or improved student outcomes (Desimone et al., 2002). Thus, this study aims to identify the characteristics of effective PD that teachers identify as most important to their professional growth. This information can be extremely beneficial to individuals that create and facilitate professional learning opportunities for teachers.

In a thorough review of the literature, there appears to be a lack of studies that directly ask teachers to reflect on the essential characteristics of effective PD. However, in one recent study, the researchers selected 34 aspects of effective teacher PD and asked school principals to consider the statements in order to "understand the perceptions principals have about effective elements of professional development and the role they play in facilitating the growth of teachers" (Brown & Militello, 2016, p. 703). While principals certainly play a role in teachers' learning by determining what PD teachers are able to participate in (Drago-Severson, 2000), it would seem important to obtain a first-hand understanding regarding teachers' perceptions of the effective characteristics of PD that have been cited by researchers in the literature. This study does not aim to refute the 34 aspects of effective PD that were used in the Brown & Militello (2016) study. However, this study closely examined the characteristics of effective PD in the literature with the goal of selecting the most appropriate set to put before adolescence education teachers to ensure broad coverage of the literature-based population of characteristics.

1.3 Study Rationale

While numerous characteristics of effective PD have been identified, additional research is needed to provide more of a consensus and synthesis around a set of characteristics (Wilson, 2013). Having a set of characteristics that can be included and measured in PD will strengthen the knowledge about what effective PD should include (Desimone, 2009). By more closely examining the characteristics of effective PD, and understanding teachers' perceptions regarding these characteristics, facilitators of PD can better align PD activities to the specific needs of the teachers being supported.

Although research exists examining the effectiveness of PD, there is still much work to do to fully understand methods for its successful facilitation (Borko, 2004). Namely, we need an

understanding of teachers' thoughts regarding the identified characteristics of PD and their beliefs about how they positively (or not) impact their learning (Guskey, 2002). Having a better understanding of what teachers feel has the most meaningful impact on their learning is important in considering a comprehensive evaluation process (Darling-Hammond & McLaughlin, 2011).

Researchers and facilitators of PD seek evaluation methods that are research-based, and are valid and reliable in nature (Blank, 2010). Such evaluation methods should consider what Fishman et al. (2003) referred to in their study as the "professional development design elements," which are those pieces that facilitators can control and modify to impact teachers' learning (p. 646). In the case of this study, Fishman et al. (2003) discussed the content focus, the strategies and locations used, and the various types of media employed as the design elements that facilitators have control over. Interestingly, these all have connections to identified characteristics of effective PD. Recognizing the potential interplay between the design elements and a synthesized list of characteristics of effective PD could then be extremely beneficial for researchers and facilitators.

1.4 A Personal Perspective

Like many, my career path has been a bit windy and has shifted a few times. One thing that has been true since I was young was that I had a natural curiosity for all things nature and medical related. Yet, it wasn't until 10th grade biology class that everything came into focus. Many of us had that one teacher that lit a spark in us, and for me this teacher made me want to pursue biology in college.

As I began college, I envisioned myself entering the medical field. To enhance my marketability to medical schools I became an emergency medical technician, working many

hours on an ambulance. I was also an emergency room technician for many years. However, by the time the middle of my junior year rolled around, I began to question choices I made. It didn't help that the same doctors I was working with at the hospital were telling me to save myself and consider a different profession as medicine "isn't as glamorous as it used to be." Struggling with what to do, I shifted to a program that would let me finish my biology degree and add an MBA with only one additional year.

As I was finishing my business degree, I took over the day-to-day operations of my dad's company due to a health emergency he experienced. His hope was that my brother or I would eventually take over the family business. This was not what I wanted for myself. The company was in no way related to science, and I was missing that part of myself. I started looking for jobs that were science related, but then the economic crash of 2008 caused job prospects to vanish as companies dealt with this catastrophe. The crash also dealt my dad's company a deadly blow, and by May of 2009, I was helping him into an early retirement as the company's doors were shuttered. This also meant I was jobless.

Sometimes it is moments like this that allow us an opportunity to reevaluate the direction we are headed. At the time I lost my job, my mom was the secretary for a school district principal. The principal knew I was struggling to find a job and, in the fall of 2009, encouraged me to submit an application to serve as a substitute teacher as the district had a great need. Teaching and education, up until that point, had never crossed my mind. As I began filling in for teachers on an almost daily basis, I realized that I was actually experiencing enjoyment for the first time in a long time. I was mainly working with elementary students and it was fun to see how inquisitive they were at that level. Then, in late fall of 2009, I had the opportunity to cover a middle school life science class. It was as if I was struck over the head...I could combine my love

of biology with the enjoyment I was having with teaching. By the end of January 2010, I was sitting through my first semester of education courses as I decided to pursue a MAT in adolescence education biology.

I could not have completed my degree in teaching at a worse time. The market for teachers in 2012 had all but dried up. There was one biology position in a 1.5-hour radius from home and there were over 100 applicants for the position. A long-term substitute that had been in the position obtained the job. Here I was to be left jobless yet again, aside from substitute teaching and a couple of business consulting jobs on the side. Again, another unexpected opportunity presented itself. A biology professor I took a course with during the MAT program approached me and asked if I would be interested in serving as an adjunct lecturer in the Biology Department. I certainly had not considered teaching at the collegiate level, but jumped at the opportunity to get a bit of teaching experience.

I fell in love with teaching at the collegiate level. Yet, adjunct pay was not something I could survive on long-term. Then, in the summer of 2013, another opportunity was presented to me. A new program, the New York State Master Teacher Program (NYSMTP), was being created. The goal of the program was to seek out the top-performing STEM teachers in New York State in order to provide them with high-quality professional learning opportunities to strengthen their content knowledge and pedagogical skill base. In turn, the intention was for these teachers to use their additional skills and knowledge to mentor other STEM teachers in the state. The end goal was to improve student achievement in STEM courses.

I was hired first as a Regional Director for the NYSMTP and then the Assistant Director for Regional Operations. I also continued to serve as an adjunct lecturer in biology. I was using my business degree, my science background, and now my experience with teaching. One thing was

lacking to solidify my position at the collegiate level, which I decided was where I wanted to stay. So, in the fall of 2015, I began the journey towards my PhD.

1.5 Interests in the Study

My passion for working with teachers has grown immensely during my time with the NYSMTP. Through this program, I have had the extreme pleasure of interacting with some of the most intelligent and driven individuals I have ever met. I get to learn something new from the teachers every day, and I have the privilege of seeking out new learning opportunities for them that can help them grow professionally as well. This is where my interest in PD was born.

Part of facilitating PD meant needing to experience PD myself. I started to sign up for various types of workshops. Some of these were one-shot opportunities. Others were more sustained in nature. What I began to recognize quickly was the quality in PD available to teachers varied greatly. Also, as I began to work with the teachers in the NYSMTP, I realized that a one-size-fits-all approach to meeting the needs and desires of these teachers would be unsatisfactory. I began to develop individualized plans for the teachers and then tried to focus on common threads between the teachers to establish learning opportunities that could bring these educators together.

As I progressed through the PhD program, I began to formulate some thoughts for a research track. Being I was working full time while pursuing my degree, it seemed to make some sense that the two (my work and my studies) could support one another. This is when I started to fixate on the quality of PD. I started a literature review and stumbled into a body of literature on the characteristics of effective PD. I soon became overwhelmed by the immense amount of information and the numerous characteristics I encountered. In thinking about the work I do to facilitate professional learning for teachers, how could I possibly design something of quality

that embodies all the claims in the literature. This is where the focus for my dissertation work began.

1.6 Theoretical Framework

In considering a framework to use for this study, I considered the goals for professional learning and development and also considered the aspects of teachers as adults. Teachers, as learners, do not come into professional learning situations as blank slates without experiences (Dadds, 2014). As such, I have focused on the work of Malcom Knowles and his adult learning theory, andragogy (Knowles 1978; Knowles et al., 2015).

A framework that takes into account teachers as learners is needed to sufficiently examine their perceptions of the characteristics of effective PD. Throughout the education research literature, there are many frameworks that have been used for the evaluation of PD. However, a more unique lens for evaluating the characteristics of effective PD through the teachers' perceptions seemed necessary to fully interpret the teachers' needs as adult learners.

Andragogy is a less-familiar term in the research literature. When thinking about teaching and learning, most are familiar with the term pedagogy, or the *study* of the theory and practice of education. Yet, the prefix "peda" refers to children (Knowles, 1978). This is typically what an educator thinks about when considering the method of delivery of content to K-12 students. Pedagogy stood as the sole theoretical framework for education well into the 1900's, and was referenced even in discussions of the education of adults (Knowles, 1978). However, studies have shown that a different approach may be considered when working with adults (Malik, 2016; Remenick & Goralnik, 2019). The term andragogy came into use as a "unified theory for adult learning" (Knowles, 1978, p. 18).

There are six core adult learning principles that have been identified (see Figure 1). These include (1) Learner's need to know (why, what, how), (2) Self-concept of the learner (autonomous, self-directing), (3) Prior experience of the learner (resource, mental model), (4) Readiness to learn (life related, developmental task), (5) Orientation to learning (problem centered, contextual), and (6) Motivation to learn (intrinsic value, personal payoff) (Knowles et al., 2015). A goal for research would be to view teachers' perceptions of the effective characteristics of PD when examined via these core adult learning principles.

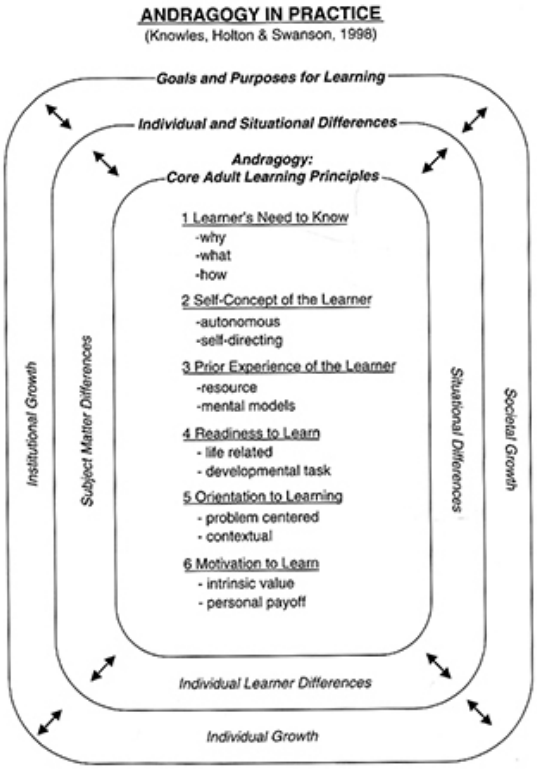

Figure 1: Andragogy in Practice. Source: Knowles et al., 2015, pp. 6.

In considering these six core adult learning principles, a place to begin is considering the distinction between pedagogy and andragogy and how the definition of pedagogy does not appropriately explain learning in adults. Adults approach learning from a different stage in their

lives. While educators often think of students as relating to John Locke's idea of a "tabula rasa", this idea does not translate to adult learning. Students may arrive to class with some background knowledge and experience, but a teacher is expected to help to mold those ideas into understanding and meaning as they support students' expansion on that knowledge (Austin, Orcutt, & Rosso, 2001). In contr,ast, teachers, as adults, have lived experiences that should be taken into consideration when designing and facilitating PD. Further, an adults' desire to learn is based on current needs, and learning is based on life situations, not content subjects (Knowles, 1978).

Adults often have limited time to dedicate to new learning (Knowles et al., 2015). For teachers, little time, if any, is provided during a school day for PD (Buczynski & Hansen, 2010; Darling-Hammond et al., 2017). Therefore, PD obligations typically fall outside of a teacher's normal work day. This means that, to participate in PD, teachers may have to consider other obligations and challenges. Teachers I have worked with often have family considerations including needing to balance child care and/or caring for parents/relatives. Others I have worked with have faced financial hardships, often requiring them to work a second job beyond their teaching obligations, which prevents them from seeking out PD that requires a financial and/or an after-school time commitment. Additionally, teachers have previously engaged in PD experiences that had varying degrees of utility for them personally that may or may not have been supportive of their growth, leading to them not wanting to participate in other professional learning opportunities (Giannoukos et al., 2015). Therefore, recognizing that when teachers are devoting time to PD, they are often being pulled away from personal time with family and other personal matters that are important. Leaders of PD will want to consider facilitating trainings that are efficient, impactful, and involve participants in an active way.

Teachers, as professionals and adult learners, desire to discuss their needs and problems, and are dissatisfied with PD that prevents them from drawing upon their experiences, (Gravani, 2012). Therefore, soliciting input from teachers while designing PD frameworks can be beneficial. Teachers are driven by goals and beliefs, and seek value-added opportunities related to their context (Vanassche & Kelchtermans, 2015). Teachers ultimately want to be able to provide some direction to their learning by choosing the subjects, and helping decide on their assessment for the program (Gravani, 2012).

What is interesting is that the six core adult learning principles seem to resonate with the research literature regarding the characteristics of effective PD. There seems to be a natural fit to consider andragogy and adult learning theory as the theoretical framework for this research. This layer of understanding is new to the research field, and examines a much-needed link between how teachers learn and their perceptions in what helps make their learning more effective.

1.7 Research Question and Methods

This dissertation study seeks to answer the following questions:

1) What do science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on characteristics of effective professional development?
2) What connections exist between the characteristics of effective professional development science and mathematics teachers view as being important to their learning and the core adult learning principles?
3) To what extent can the continually growing list of characteristics of effective professional development be narrowed down to specific factors that can be considered when designing professional learning activities for science and mathematics teachers?

1.7.1 Type of Study Being Conducted

This research study employed the use of a Q methodological survey to examine the teachers' perceived views of specific characteristics of effective PD. Q methodology is a robust and versatile mixed-methods approach that can provide quantitative statistical data and supporting qualitative data. For this study, that means a more complete analysis of teachers' perceptions regarding the characteristics of effective PD can be obtained.

1.7.2 Data Collection Procedures

An online software package called HTMLQ was utilized to collect data for this study. Participating teachers were provided with a URL taking them to the site where the Q survey was set up. Each teacher was provided with a unique access code to enter the survey. Upon entry, participants completed an online consent form and then began the sorting process. First, participants were presented with a sample set of statements (known as the Q set) that is meant to be a representative sample of all statements on a subject (in this case, characteristics of effective PD). Participants were asked to examine the statements comprising the Q set (n=44) and separate them into three different groupings (Most Identify With, Neutral, Least Identify With). Once this task was completed, participants further refined their selections by placing their choices onto a Q sort distribution grid. A forced-choice normal distribution was used, from +5 to -5 (Watts & Stenner, 2012). The Q sort provides the subjective view of the participant on the topic being studied (Watts & Stenner, 2012).

Following the completion of the Q sort, participants were provided with a questionnaire where they had the opportunity to provide a rationale for the choices made during the sorting process. Specifically, participants were asked to explain why they chose the items with which they most identified with and to explain why they chose the items with which they identified

with the least (corresponding with the items that fell under the +5 column and the items that fell under the -5 column). Finally, teachers were asked to answer a set of questions that provided descriptive data points that helped with data interpretation.

1.7.3 Item Selection

A thorough literature review was completed centered around the effective characteristics of PD. The population of statements (concourse) was then examined and any statements that were duplicative in nature were eliminated. Remaining statements were stratified into six categories based on the six core adult learning principles of andragogy (Knowles et al., 2015). A representative sample (n=44) was then taken from these six categories to create the Q set.

1.7.4 Participant Selection

The participants for this study were composed of teachers from the NYSMTP that that have completed their four years of participation within the program. There are many reasons why this population was selected for this study. First, in addressing the research question of teachers' views on characteristics of effective PD, these are teachers who have completed four years of intensive professional learning. They were required to complete a minimum of 50 hours of professional learning through the NYSMTP for each of the four years they were in the program (a total of 200 hours of professional learning over four years). This professional learning requirement was in addition to any district requirements for professional learning that they were responsible for completing, and was in addition to any state requirements they had to complete to maintain their teaching certification(s) in New York State. Second, by using emeriti of the program, they no longer are part of the NYSMTP and therefore have no reporting responsibilities to the program. This is important to note since, as mentioned, I currently serve as the Assistant

Director for the NYSMTP. Therefore, participants are no longer obligated to respond to requests associated with the NYSMTP. Third, in having helped facilitate professional learning for this group of teachers, it is valuable to see the teachers' perspectives regarding their professional learning experiences through the NYSMTP so that improvements can be made to professional learning opportunities facilitated through the program for current and future teachers enrolled.

Participation was limited to those that were still actively teaching. At the time of this study, there were 553 emeriti master teachers from across New York State that were identified. A random sample of 100 names was drawn for this study and all were invited to participate by taking the Q methodological survey. The goal was to get 45-50 responses. Additional teachers from the original population (50 additional teachers) were contacted at random as not enough teachers responded to the first request.

1.7.5 Data Analysis Plan

Once the data for the Q sorts was received from the participants, the information obtained was then subjected to a set of 3 statistical operations that included correlation, factor analysis (principal components analysis), and computation of factor scores (McKeown & Brown, 2013). Additionally, participants were provided with a questionnaire where they had the opportunity to provide a rationale for the choices made during the sorting process. Relevant demographic information was also collected to help interpret the data. Based on the statistical data and additional information collected from the teachers, factor interpretation proceeded.

1.8 Thesis Organization

This chapter has provided an introductory look for this dissertation thesis. Chapter 2 contains a review of PD literature as related to highly effective PD and its associated characteristics.

Chapter 3 describes the mixed-methods approach utilized for collecting, organizing, and analyzing the data for this study. Chapter 4 is a report of the results. Chapter 5 is a discussion of the findings and implications for considering the facilitation of effective PD. Within this chapter is also discussed the limitations of this study and potential areas for future research opportunities.

1.9 Definitions of Terms

Some terms were used by the researcher in this study and are defined as follows.

Adolescence Education: This term is used in this study to describe education that occurs at the middle- and high-school levels (grade levels 7-12 for this study).

Andragogy: For the purpose of this study, andragogy and adult learning theory have been used interchangeably. Knowles et al. (2015) have defined andragogy as, "any intentional and professionally guided activity that aims at a change in adult persons" (pp. 39-40). Unlike pedagogy that is the approach used with children, and Knowles defines quite literally as "the art and science of leading children" (pp. 9-10).

Characteristics of Effective Professional Development: This idea is discussed in greater detail in chapter 2. Education research references "features", "elements", or "characteristics" of effective PD (Darling-Hammond et al., 2017; Guskey, 2003; Main et al., 2015). In general, it is those things that help to make PD effective for participants. In this study, the term "characteristics" has been selected for uniformity to represent all three (features, elements, characteristics).

Concourse: This is the overall population of items (statements in the case of this study) for a particular topic or subject matter. The Q set (or Q sample) is drawn from the concourse. This process is further described in Chapter 3.

Effective Professional Development: Again, an entire section in Chapter 2 is dedicated to defining this term. To summarize here, effective PD consists of learning opportunities that lead

to improved student learning outcomes as a result of changes in teacher confidence, teacher effectiveness, and enhanced pedagogical practices (Darling-Hammond et al., 2017; Main et al., 2015).

Facilitator: As referenced in this study, these are individuals that are often responsible for designing and/or conducting professional learning activities for educators.

Master Teachers: The teacher participants in this study are emeriti of the NYS Master Teacher Program (www.suny.edu/masterteacher). Details regarding these participants are presented in Chapter 3. To be named as a *Master Teacher*, K-12 STEM teachers can apply to the program, and are required to go through a competitive and rigorous selection process. Teachers in grades 7-12 must teach STEM courses for a minimum of 60% of their teaching load. Additionally, they must have a minimum of 4 years of teaching experience.

P Sample: (or P Set) In Q methodology, this refers to the participants in the study. Participant selection is often strategically executed in Q methodological studies and are a function of the research question being answered (Watts & Stenner, 2012). The use of small numbers of participants is typical in these studies (Thomas & McKeown, 2013).

Q Set: (or Q sample) In Q methodology, this refers to the representative set of items (statements for this study) drawn from the concourse of items. These items are then presented to participants in the study to be used during the Q sorting process, as described in Chapter 3.

Chapter 2: Literature Review

2.1 Introduction

Teacher PD is a topic that has been examined in detail by many researchers over the course of decades (Sample McMeeking et al., 2012; Wayne et al., 2017). Yet, there are still many areas of interest for researchers, and questions continue to linger that need to be answered. One particular topic that requires additional evaluation is the characteristics of effective PD. This chapter will describe the current driving forces for teacher professional learning, explore the definition of effective PD, and discuss the currently described characteristics of effective PD. It will then outline the reasons that this area warrants additional study. Numerous lists of characteristics that exist in the literature demonstrate that, while there is a consensus being established around some characteristics, more work is needed to reach broader agreement amongst the education community. Future research needs to work towards synthesizing a set of essential features that can be utilized by designers and facilitators of PD and integrated across all professional learning opportunities. Additionally, researchers need to bring teachers into the evaluation and research being conducted around these characteristics to determine which ones they believe are instrumental in their learning of new skills, practices, and knowledge.

2.2 Defining Professional Development

PD for teachers is a heavily researched area in the education field due to the importance it plays in supporting reform efforts in education. Learning as a teacher is an ongoing process that continues throughout an individual's career that does not end with graduation from college (Evers et al., 2016). Most teachers continue to pursue additional training, either because of their own self-identified needs and volition, or by mandate (often by district administrators or state

policy). Teachers seek professional learning opportunities to stay on top of shifting trends in education resulting from the continual expansion of content knowledge and pedagogical knowledge, especially in the areas of science and technology (Evers et al., 2016; Merchie et al., 2018). Ongoing lifelong learning and the need to constantly adapt classroom practice is stressed (e.g., by administrators; by policy makers) to ensure educators have the requisite skills and knowledge to meet the changing needs of students (Gravani, 2012; Kelly & Cherkowski, 2015).

Teachers, like many other professionals (e.g., lawyers, doctors) have regular ongoing learning as an expectation of their careers (Webster-Wright, 2009). PD in the context of this literature review refers to activities and learning experiences that are designed specifically for teachers with the expressed goal of providing changes in teachers' knowledge, skills, or attitudes, and leads to improved student learning outcomes (Evers et al., 2016; Wilson et al., 2015). Supporting teachers' learning as they transform new knowledge into practice is not a simple task, and many things can impact success including a teacher's commitment, willingness, and skills to adapt their teaching methods (Avalos, 2011; Poekert, 2012). In other words, there are many confounding variables to consider in education when contemplating the success of PD opportunities and their impacts on teachers and students.

The structure of PD programs can vary greatly. Most recognizable would be the formal and structured experiences teachers participate in that include single- and multi-day workshops, conferences, summer institutes, mentoring sessions, learning communities, and research opportunities, as examples (Desimone, 2009; Wilson, 2013; Wilson et al, 2015). Informal professional learning can occur via simple unstructured conversations and collaborations with a colleague regarding instructional methods that are being utilized (Desimone, 2009). Increasingly

common in terms of collaborations amongst educators is the use of learning communities where teachers have a bit more agency in guiding their learning with one another.

2.3 Drivers of Professional Learning

While for many teachers, PD represents an opportunity to extend their content knowledge and improve their practice (Patton et al., 2015), for most it is also a required part of their employment to maintain certification/licensure and to satisfy contractual obligations (Guskey, 2002; Lieberman & McLaughlin, 1992). As such, education policy and school administrators are the typical driving forces of mandated participation in PD. Their mission is to seek improvements in teaching quality that they believe will positively impact student achievement (Desimone et al., 2006). The *No Child Left Behind Act* (NCLB) came about nearly two decades ago, yet a review of the education research literature is peppered with references that demonstrate the impact this policy has had on teacher professional learning. NCLB provided an expectation that all teachers needed to be highly qualified, and funding organizations were very interested in PD projects that tied teacher PD to student achievement (Loucks-Horsley & Matsumoto, 1999; Sample McMeeking et al., 2012). Funding streams have a large influence on the decisions made in education (Longhurst et al., 2016), and PD is a multi-billion-dollar investment made at the local, state, and federal levels (Desimone, 2009; Longhurst et al., 2016; Wayne et al., 2008). As such, states and districts are often obliged to hit certain targets based upon teacher and student performance in this incentivized environment (Loucks-Horsley & Matsumoto, 1999).

More recent reform movements such as Race to the Top (RTT) have caused states to implement accountability measures for teachers (e.g., Annual Professional Performance Review (APPR) in New York State), to meet state education achievement targets (e.g., in the case of

APPR, students testing scores that are tied to evaluations of a teacher's practice in the classroom) (Richmond & Manokore, 2011; Sample McMeeking, 2012). Since programs like NCLB and RTT require states to compete for available education funding that is linked to student achievement, this has led to states and districts creating PD programs geared towards improving teachers' effectiveness to enhance student achievement (Wilson et al., 2015). This of course assumes that the remedy for correcting all that is wrong with education is increased amounts of professional learning for teachers (Brown & Militello, 2016), and ignoring other potential variables that undoubtedly impact teaching, learning, and student achievement. It is all too common to find PD linked to educational improvement plans and research studies, especially in situations where stakeholders in education (e.g., administrators, policymakers, parents) expect improvements in student learning outcomes (Longhurst et al., 2016; Merchie et al. 2018).

Educational leaders and district administrators seek PD initiatives that better support efforts to reenvision teaching and learning, and adequately supports teachers as they are encouraged to adapt and grow (Darling-Hammond & McLaughlin, 2011; Drago-Severson, 2000). However, teachers need to be brought into this equation as they are the ones that can help to champion change in education systems (Krainer, 2015). After all, they are positioned on the front lines each day, and can provide first-hand information and data on the impacts of recommended changes. Traditional models of PD where direct dissemination of information to participants has often been the mode for learning must be updated to recognize the needs of teachers as adult learners (Darling-Hammond & McLaughlin, 2011, Drago-Severson, 2000). Teachers "continue to grow and develop while working in schools" (Drago-Severson, 2000, p. 31), and therefore teacher learning should be focused more on a sharing of issues teachers face in their day-to-day practice (Darling-Hammond & McLaughlin, 2011). This means providing opportunities for educators to

choose learning activities that best fit their needs instead of limiting them to pre-determined opportunities that promote a one-size-fits-all approach (Lieberman, & McLaughlin, 1992; Patton et al., 2016).

Teachers, as professionals and adult learners, desire to discuss their needs and problems, and are dissatisfied with PD that prevents them from drawing upon their experiences (Gravani, 2012). Therefore, soliciting input from teachers while designing PD opportunities can be beneficial to program facilitators. Teachers are driven by goals and beliefs, and seek value-added opportunities related to their context (Vanassche & Kelchtermans, 2015). Teachers ultimately want to be able to provide some direction to their learning by choosing the subjects that they will study and helping to decide on the assessment strategies for the programs they participate in (Gravani, 2012).

2.4 Effectiveness of Professional Development

As has been noted, the creation and implementation of PD for teachers has been widely studied by education researchers. One area of specific interest is in the effectiveness of PD (Darling et al., 2009; Desimone et al., 2006; Guskey, 2003). It seems that often the weight of education reform is placed on the results of PD, and measuring its impact is critical (Kennedy, 2005). If the objective of professional learning is to impart new knowledge and skills on teachers so they can better grasp how students learn, then understanding the effectiveness of PD through this particular lens of student achievement would be of great importance (Darling-Hammond & McLaughlin, 2011; Desimone et al., 2002; Fishman et al., 2003).

As such, the challenge appears to lie in defining what effective PD is, and many varying ideas exist across literature (Cochran-Smith & Lytle, 1999). Researchers suggest effective PD should consist of learning opportunities that lead to improved student learning outcomes as a

result of changes in teacher effectiveness and enhanced pedagogical practices (Darling-Hammond et al., 2017; Main et al., 2015). Changes in teacher effectiveness involves the shifting of teachers' beliefs and attitudes about their practice and is not just about learning new skills (Fishman et al., 2003; Vanassche & Kelchtermans, 2016). Effective PD considers both of these elements (new skills and new beliefs) in tandem (Guskey, 2002; Jeanpierre et al., 2015). As teachers grow more confident in their abilities to implement new knowledge and skills in the classroom, change can be realized in the providing of novel and innovative learning opportunities for students (Jeanpierre et al., 2015; Stolk et al., 2011).

To enhance pedagogical practice, it is suggested that teachers need to have the opportunity to take on the additional role of learner, where they can experience struggle as their own students would in learning something new (Darling-Hammond & McLaughlin, 2011). By creating an opportunity for contextualized learning, facilitators of PD can support teachers by having them engaged in actual problems, through examining actual student work, and by providing time for reflection on their learning process (Darling-Hammond & McLaughlin, 2011; Vanassche & Kelchtermans, 2016). The expectation is that teachers can better understand how students learn when they are working through real problems and applying real strategies during PD sessions (Sample McMeeking et al., 2012). Lieberman (1995) discussed a "continuum" of practices that encourage teacher growth, moving teachers from direct teaching to encouraging learning (p. 3). This continuum is supported when teachers understand the ways in which students learn, since teaching and learning is enhanced by teachers feeling more effective in their practice (Ramlo, 2012).

Further, effective PD is looked at as not only a spark to improve individual teachers' abilities, but can lead to broader school-wide improvements through additional learning

opportunities for all teachers (Soine & Lumpe, 2014). While PD efforts are usually targeted at an individual teacher's learning experiences, effective change in education happens when impacts can be seen at the entire school level and beyond (Darling-Hammond et al., 2017; Richmond & Manokore, 2011). However, many barriers to schoolwide implementation exist including limited time being allotted to implement new skills and knowledge, a lack of materials and other resources (e.g., technology, lab equipment), mandated curriculum that limits bringing in outside information, and a scarcity of opportunities for teachers to collaborate (Buczynski & Hansen, 2010; Darling-Hammond et al., 2017).

2.5 Evaluating Effectiveness of Professional Development

The evaluation and effectiveness of the many PD initiatives varies greatly (Merchie et al., 2018). In evaluating the effectiveness of PD opportunities, researchers must determine what to evaluate and how to evaluate these things in an orderly and replicable way (Merchie et al., 2018). In terms of how to evaluate PD, researchers often rely on summative and formative feedback provided by teachers during or after a particular learning opportunity (Arbaugh et al., 2015). Posttests (summative evaluations) are often relied upon as an assessment of a particular learning opportunity (Ramlo, 2012). Such evaluations rely on teachers' perceptions in answering what is being evaluated (Arbaugh et al., 2015). This is typically teachers' perceptions as to the extent in which a particular PD opportunity has increased their knowledge, shifted their beliefs, and improved their teaching practice (Arbaugh et al., 2015; Darling-Hammond et al., 2009). Often, Likert-style questions are utilized as a quick and easy way to capture teachers' thoughts, while open-ended questions and interviews are occasionally found in studies (Stolk et al., 2011).

Problematic in many of these evaluations would seem to be the fact that evaluators are measuring a teachers' beliefs at the time the professional learning happens, when teachers have

not yet had an opportunity to reflect on their new learning and to implement it into their classroom. Additionally, what teachers learn in a PD setting is not necessarily immediately transferrable to the work they are doing in their classrooms (Loucks-Horsley & Matsumoto, 1999). Teachers must often modify or adapt new skills and knowledge to foster greater achievement across diverse student populations (Darling-Hammond et al., 2017). This last point is especially important as the definition of effective PD is regularly tied to subsequent improvements in student achievement (Darling-Hammond et al., 2017). Yet, student learning is typically not considered a part of the research and evaluations of PD by researchers (Loucks-Horsley & Matsumoto, 1999). To accomplish this would require longitudinal studies, following up with teachers after implementation of an intervention, and having available access to student information. These additional steps, especially having the ability to collect information on student achievement, can be much more challenging to accomplish as a researcher. As such, researchers then often look to students' scores on standardized testing as these measures are easier to obtain. Yet, it is difficult to isolate the educations impacts of one particular intervention and tie it directly to standardized testing scores of students' achievement (Fishman et al., 2003).

Many studies have not evaluated the effects of PD in a quantitative manner, but rather rely on measures such as teacher attendance and increases in self-reported teacher knowledge (Desimone et al, 2002; Loucks-Horsley & Matsumoto, 1999) to determine the effectiveness of PD. Various tools used over the past several decades (e.g. surveys, classroom observations, interviews) are meant to measure the effectiveness of PD, and while some are more theory-based, many are built upon what is practical to accomplish for a researcher (Heath, 2010). Interviews and open-ended questionnaires are tools that can help researchers gain a deeper insight into what teachers are thinking and feeling, yet such qualitative data can pose the risk of interjecting researcher bias,

and teachers answering questions in the way they believe they are expected to answer (Stolk et al., 2011).

Facilitators of professional learning opportunities stand to learn a great deal about the work they do and the effectiveness of the PD they conduct for teachers by utilizing the best evaluation measures (Arbaugh et al., 2016; Desimone, 2009). Since teachers are relied upon for the improvement of educational outcomes (Lee et al., 2008), Loucks-Horsley & Matsumoto (1999) share that understanding the "(a) content, (b) process, (c) strategies and structures, and (d) context of quality professional development" are all pieces that should be evaluated in educational research on effective PD (p. 264). Therefore, PD should include evaluation components that consider teachers' satisfaction, the extent to which they obtained new knowledge and skills, and assesses longer-term measures such as teachers' ability to implement new interventions and if student outcomes improve (Loucks-Horsley et al., 1996).

2.6 Characteristics of Effective Professional Development

Issues have been documented around the success and effectiveness of PD for teachers, including poor evaluation techniques (Cormas & Barufaldi, 2011), a lack of attention to the processes of PD (Stolk et al., 2011), and instances where PD is too far removed from the context and needs of teachers (Buczynski & Hansen, 2010). Although researchers had defined the meaning of effective PD, more work was needed to determine what ideas comprise the makeup of effective PD (Fishman et al., 2003). Lists began to emerge from researchers and funding agencies that described characteristics of effective PD (Cormas & Barufaldi, 2011), with the intent of assisting facilitators of PD in the design of professional learning opportunities (Cormas & Barufaldi, 2011; Desimone, 2009). Researchers then became interested in those key aspects of effective PD that lead to its successful outcome(s) (Penuel et al., 2007). These aspects are

currently being referred to in education research as the “features”, “elements”, or “characteristics” of effective PD (Darling-Hammond et al., 2017; Guskey, 2003; Main et al., 2015). In this study, the term “characteristics” has been selected for uniformity to represent all three.

In keeping with the idea that improving teacher practice leads to enhanced student outcomes, researchers have sought to define those characteristics of PD that make a particular learning activity effective in doing so (Desimone, 2009). Extensive reviews of literature have been conducted to isolate those characteristics that are included in the design and implementation of PD opportunities that claim to have led to successful learning and change in participating teachers (Darling-Hammond et al., 2017). As an example of the significance and weight these characteristics began to hold, according to Merchie et al. (2018), 31% of the studies (54 total manuscripts studied) they examined for their particular literature review discussed one or more characteristics they could identify as “core” or “structural” features, or characteristics, of PD as part of the intervention being used (p. 148).

Studies suggest that PD experiences that include these characteristics in their design can have a “substantial, positive influence on teachers’ classroom practice and student achievement” (Desimone et al., 2002, p. 82). An example of an identified characteristic of PD is *when a learning opportunity includes an explicit focus on subject matter, teachers can develop increased content understanding* (Borko, 2004). The thought is that when teachers possess a deeper level of content knowledge, they are likely to be more confident in teaching their particular subject area (Fetters et al., 2002). A second example would be that *by engaging teachers in activities designed for their students, this leads to teachers implementing more active-learning strategies in their classroom* (Darling-Hammond et al., 2017). Teachers have the ability to become active

learners to experience what their students feel like when experiencing a new activity or being taught a new skill for the first time (Liebermann, 1992). In preparing for this review, 107 characteristics like these were recorded, although some are similar in their context if considering nuanced shifts in the way the language around the characteristics are written.

While studies have tied effective PD to teacher learning and student achievement, there have actually been relatively few studies that have linked these two in a causal manner (Sample McMeeking et al., 2012). Even so, researchers have pushed to test the use of practices or characteristics that are considered to be a part of effective PD in an effort to build a consensus for designing and facilitating PD (Enderle et al., 2014; Wayne et al., 2008; Wilson, 2013). Researchers are curious in knowing more about the design elements and activities that lead to effective PD (Enderle et al., 2014). Studies are now beginning to examine how many characteristics need to be included for PD to be effective and how to ensure that such characteristics are actually integrated into the design of the PD (Desimone, 2009; Merchie et al., 2018).

2.7 Agreement over Effective Characteristics (*Gap in the Literature*)

As one would imagine, agreement amongst researchers on a set of characteristics for effective PD has been challenging to establish (Main et al., 2015). While some researchers would argue that a professional consensus is forming around a set of characteristics found in effective PD (Desimone et al., 2002; Desimone, 2009; Wayne et al., 2009), when Guskey (2003) examined the literature for characteristics of effective PD, he found 13 lists that "vary widely and that the research that supports them is inconsistent and often contradictory" (p. 748). The characteristics in which there appears to be some agreement in thinking about effective PD include: a focus on content knowledge, applying active learning strategies, ensuring that

professional learning is coherent with current teachers' needs and situation, that the duration is more long-lasting than one-time events, and that there is collective participation and networking amongst attendees (Desimone et al., 2002; Wayne et al., 2008, Wilson, 2013).

The same researchers that discuss the consensus that exists around these characteristics discuss limitations regarding the consensus that has formed. Desimone et al. (2002) stated, "there is little direct evidence on the extent to which these characteristics are related to better teaching and increased student achievement" (p. 82), which, as pointed out earlier, is included as part of the definition of effective PD. Seven years later, Desimone (2009) stated similarly that "there is no clear guidance indicating the thresholds required to achieve consensus" (p. 183), and questioned, "whether showing effects on teaching practice is enough to count a characteristic as effective, or whether only links to improved student achievement warrant the "effectiveness" label" (p. 183). Wayne et al. (2008) contended "the evidence on the specific features that make a difference for achievement is weak, and the consensus falls short of addressing several practical questions faced by those who design and fund PD" (p. 469).

As evidenced in the literature, total agreement in the research community does not exist around the characteristics of effective professional learning, yet the quality of PD may be improved by seeking to understand and define common characteristics (Guskey 2003). More importantly, a gap in the literature exists in considering the characteristics of effective PD, namely, what are teachers' thoughts and beliefs regarding these characteristics and how they impact their learning through PD opportunities (Buczynski & Hansen, 2010). In undergoing a search for effective PD, over 180,000 articles were populated in the search list. However, after going through several hundred of these articles, nothing was encountered for research that involved teachers thinking, thoughts, or beliefs around these characteristics. Understanding those

characteristics that teachers perceive as important to their learning is in line with the goal of understanding if PD programs are truly successful in reaching their target audience (Desimone et al., 2006).

Much of the focus for teacher evaluations of PD has been relegated to their satisfaction and commitment to implementing change, and not as much on the design of PD (Desimone, 2009). Nevertheless, research suggests the importance that the design of PD plays in shifting teacher practice (Darling-Hammond et al., 2009). If teachers are not active participants in the designing of PD programs by sharing their needs and problems, they may not be committed to the PD offering (Gravani, 2012). Likewise, teachers being expected to implement curriculum in certain ways that do not meet their needs are unlikely to implement that curriculum (Flory et al., 2013). As such then, when designing PD using a set of characteristics, it would be extremely beneficial to have teachers' input on the use of those characteristics, especially since teachers are often subjected to PD opportunities that fail to encompass the use of these purported characteristics of effective PD (Poekert, 2012).

Since there is a lack of broad consensus around a set of characteristics, and there are numerous identified characteristics in the literature, a research protocol that includes evaluating teachers' thoughts could help narrow the list. This provides an opportunity for continued research to refine the numerous lists of characteristics of professional learning. The hope is that in considering the many identified characteristics of effective PD that exist in the literature, that through additional research methods, the list may be narrowed down to some essential characteristics that teachers find are important to their professional growth and learning. By seeking to better understand these characteristics and determining their importance in designing

and facilitating PD, the work of individuals providing professional learning opportunities for educators may be enhanced through their incorporation.

2.8 Impacts on Facilitators of Effective Professional Learning

Individuals involved in the crafting and leading of effective PD strive to systematically consider the impact of their work (Guskey & Yoon, 2009). Researchers and facilitators of PD, therefore, seek evaluation methods that are research-based, and are valid and reliable in nature (Blank, 2010). Such evaluation methods should consider what Fishman et al. (2003) referred to in their study as the "professional development design elements", which are those pieces that facilitators can control and modify to impact teachers' learning (p. 646). In the case of this study, Fishman et al. (2003) discussed the content focus, the strategies and locations used, and the various types of media employed as the design elements that facilitators have control over. Interestingly, these all have connections to the identified characteristics of effective PD. Recognizing the potential interplay between the design elements and a synthesized list of characteristics of effective PD could then be extremely beneficial for researchers and facilitators.

Facilitators need to consider the motivations of educators for seeking out and participating in professional learning (Wayne et al., 2008). While policy makers are often looking to reform education, typically to drive up student achievement scores, this is not characteristically the motivator for teachers that participate in PD opportunities. Teachers are generally more interested in improving their personal practice that impacts the day-to-day work they do with their students (Vanassche & Kelchtermans, 2016). Failure to grasp what motivates teachers to participate in PD is a critical reason PD does not succeed (Guskey, 2002). As such, facilitators may want to ascertain the teachers' goals and needs prior to facilitating a professional learning experience. One potential solution for facilitators is to consider ways in which teachers can be a

part of the planning and implementation of PD programing, and integration of new learning into the schools in which they teach (Lieberman, 1995). Facilitators can more successfully support teachers' integration of new ideas if they are able to understand teachers' thoughts and beliefs regarding changes being introduced (Fetters et al., 2002).

Another point for facilitators to consider is that teachers, like students, learn in various ways, and there should be a range of different learning experiences for teachers to participate in (Jeanpierre et al., 2005). In addition to workshops, PD providers may consider activities like book clubs, professional learning communities and workgroups, and action research based on their implementation of new skills and knowledge (Brown & Militello, 2016; Desimone, 2009). Drago-Severson (2000) discusses six models for PD that are most frequently utilized: (i) training; (ii) observation/assessment; (iii) involvement-in-an-improvement process; (iv) inquiry; (v) individually guided or self-directed; and, (vi) mentoring models (p. 4). These models range from short-duration opportunities (trainings) through more robust and longer-duration experiences (improvement process). Self-directed opportunities provide teachers with the agency to help guide their learning path instead of always relying on a top-down or expert-learner approaches (Drago-Severson, 2000). Exploring ways to engage teachers more in the design of PD is supported by what is known about adult learning as well. Teachers have past experiences that can be leveraged in thinking about raising quality in education (Dadds, 2014). It will be necessary to determine how the roles of teachers and PD facilitators may shift if some of the responsibilities for designing professional learning opportunities become shared (Livneh & Livneh, 1999). If teachers are to be part of designing and facilitating their own professional learning, they will need additional supports to embrace this role as responsibilities shift for both facilitators and educators (Livneh & Livneh, 1999).

Similarly, when thinking about models for PD, facilitators may want to consider the strategies being employed while facilitating professional learning. In looking at a study completed by Loucks-Horsley & Matsumoto (1999), they outlined five categories of strategies for PD. These include (i) Immersion; (ii) Curriculum; (iii) Examining practice; (iv) Collaborative work; and, (v) Vehicles and mechanisms (p. 264). For *immersion* and *curriculum*, this means engaging teachers in the actual learning processes that students will be encountering when the new knowledge and skills learned are integrated back into the classroom (Sample McMeeking et al., 2012). In thinking about *examining practice*, short of being able to observe teachers in action with students, this may include examining student work samples to reflect on what one can uncover about their students' thinking and learning (Loucks-Horsley & Matsumoto, 1999). The fourth strategy, *collaborative work*, involves ensuring there are sufficient opportunities for teachers to engage with other teacher learners, perhaps within their own school or content area, or across other schools (Lakshmanan et al., 2011). Finally, for *vehicles and mechanisms*, this refers to the actual delivery method for learning, such as a workshop or conference (Loucks-Horsley & Matsumoto, 1999). In reflecting on the evaluation efforts of researchers and facilitators of effective professional learning, it may be prudent to consider evaluating PD opportunities against these five strategies as they also seem to encompass several identified characteristics of effective PD.

2.9 Secondary STEM PD

National science and mathematics standards emphasize the importance of increased rigor as well as the integration of other disciplines (STEM integration) (CCSSI, 2010; Fulmer et al., 2018; NRC, 2013). For example, the Next Generation Science Standards call for 3-Dimensional Learning that incorporates science and engineering practices, disciplinary core ideas, and cross-

cutting concepts (NGSS Lead States, 2013). Addressing science instruction and learning through this new approach is a substantial shift from the practices teachers were familiar with (Bybee, 2014; Duschl & Bybee, 2014). Additionally, the Next Generation Science Standards makes explicit connections to the Common Core Math Standards, reinforcing the interconnectedness between the disciplines (Bybee, 2014).

In order for teachers to integrate these learning expectations into their curriculum, they will need to adapt their teaching practices (Banilower et al., n.d.). Teachers are being asked to address learning through approaches they themselves have not experienced (Longhurst et al., 2016). As such, recent education research literature has emphasized the importance of PD for STEM teachers. However, in order to meet the expectations of the reforms called for in the new science and mathematics standards, the growth and learning that educators need cannot be met with a one-off workshop. Instead, there are calls for great investments in PD that is of long duration (multi-year in nature), includes extended sensemaking activities, and includes the participation of all stakeholders responsible for helping students learn (Allen & Penuel, 2015; Longhurst et al., 2016; McGee & Nutakki, 2017).

2.10 Additional Research Considerations

As has been demonstrated, there are numerous claims as to what are considered the characteristics of effective PD. This ever-growing list starts to become unmanageable when considering what characteristics should be included in the design of high-quality PD opportunities. While it may seem obvious that a natural next step would be to start isolating characteristics to evaluate their impact on teacher learning, there is yet to be a set of characteristics that researchers have agreed upon to regularly study in a quantitative manner (Desimone, 2009; Wilson, 2013). Further, while some researchers have coalesced around at least

some shared characteristics, evidence is lacking in terms of how much of a role a particular characteristic plays in the success of teacher learning, and how often that characteristic must be included in the design of professional learning experiences for it to impact teacher learning (Desimone, 2009; Gravani, 2012).

While research exists around the effectiveness of PD, there is still much work to do to fully understand methods for its successful facilitation (Borko, 2004). Namely, we need an understanding of teachers' thoughts regarding the identified characteristics of PD and their beliefs about how they positively (or not) impact their learning (Guskey, 2002). Having a better understanding of what teachers feel is best for their learning is important in considering a comprehensive evaluation process (Darling-Hammond & McLaughlin, 2011).

While effective PD is relied upon by districts and administrators to address issues in education, it should be noted that additional professional learning is not all that is needed (Desimone et al., 2002). Likewise, the effectiveness of PD cannot be the only consideration for the success of professional learning opportunities. Effective PD is not the cure-all for the many issues that plague education, and considerations such as the context and the community of the educators participating in professional learning need to be considered (Krainer, 2015). Participating in learning opportunities, while sometimes is voluntary, is often compulsory for teachers, and their motivations to participate may vary greatly (Desimone et al., 2002; Wayne et al., 2008). Teachers participate in various types and quality of professional learning over the course of their career (Desimone et al., 2002), and sometimes PD execution misses the mark for the attendees. Desimone et al. (2002) explained, "Our results suggest that change in teaching would occur if teachers experienced consistent, high-quality PD. But we find that most teachers do not experience such activities" (p. 105). There are plenty of references in the research

literature that indicate that some questions remain about what and how teachers are able to learn through participation in PD (Health et al., 2010; Wilson, 2013).

If teachers are not vested in changes that are being implemented, then the success of those changes is hindered (Vanassche & Kelchtermans, 2016). Further, if some teachers are choosing to not participate in professional learning, then the intended shifts in education being sought are more challenging to realize (Kelly & Cherkowski, 2015). Since PD programs often focus on content and pedagogical knowledge to improve teacher learning and student outcome (Wilson, 2013), many different approaches and angles must be considered to fully understand if programs have met their learning objectives and follow best practices for success (Hill et al., 2013; Borko, 2004). Teachers also bring with them prior experiences and knowledge (Patton et al., 2015). Program facilitators that fail to acknowledge that teachers do have prior knowledge, and do not attempt to understand what that prior knowledge means for the design of their learning experiences, will likely not meet the needs of the learners (Patton et al., 2015). Education research needs to consider how knowing this information can lead to the design of more effective PD opportunities (Gravani, 2012).

Successful change typically does not result from one professional learning experience. Therefore, looking to create a system of ongoing learning should be considered (Loucks-Horsley et al., 1996). Ongoing learning should consider the importance of supporting teachers through implementation in-between formal learning experiences (Patton et al., 2015). Looking at the role teachers can play in the design and implementation of PD is as also important because they can provide the support for each other (Lieberman & McLaughlin, 1992), as well as assist facilitators in designing professional learning experiences that teachers are more likely to engage in (Loucks-Horsley et al., 1996). Additionally, empowering teachers to take on roles of support and

design provides teachers opportunities to explore teacher leadership as a way to help influence colleagues through collaboration to create change (Poekert, 2012). There is still much research that needs to be conducted to understand the role teachers can play in supporting changes in education policies and practices (Darling-Hammond & McLaughlin, 2011).

Since teachers do have varying background knowledge and experiences, a range of PD experiences must be created to meet the individualized needs of teachers, moving away from the *one-size-fits-all* approach (Darling-Hammond & McLaughlin, 2011; Lieberman 1995). To support changes in teachers' behaviors and feelings of effectiveness, facilitators should consider incorporating ways for participants to interact with one another and provide time for reflection; to help them make sense of their learning (Kelly & Cherkowski, 2015). To support this work, having a concise list of effective characteristics in which a consensus exists amongst most education researchers would help in the design of PD. Of course, as Desimone (2009) states, "This is not to say that each study should be prevented from having its own unique characteristics or would be constrained to measuring only the features in a core framework" (p. 186). Rather, these characteristics should be evaluated in conjunction with teachers so they can inform which characteristics they find most supportive to their learning.

2.11 Summary

In summary, this chapter served to provide a look at how the literature views effective teacher PD in order to set up the basis for this research study. Recommendations for reforms in education often include high-quality and effective PD as a means to enact change (Guskey, 2002). Considering the amount of time and money invested in PD programs, it seems to make sense to want to include in the design those characteristics with which teachers view as effective for their learning needs (Desimone et al., 2002). While teachers have often lacked the ability to

choose the PD they desire, research suggests teachers are attracted by opportunities to expand their knowledge and skills, and to enhance their work with students (Guskey, 2002; Lieberman & McLaughlin, 1992). Learning opportunities that are unable to address the needs of teachers will likely not succeed as teachers avoid such PD (Guskey, 2002; Lieberman & McLaughlin, 1992).

Undoubtedly, reforms in education are complex in nature, requiring the participation of many groups working together, including administrators, PD facilitators, and teachers (Fetters et al., 2002). The teachers' voices should be considered as an important aspect in realizing change as their beliefs about PD and change can impact the success of a particular effort (Dadds, 2014; Fetters et al., 2002). Further, research indicates that teachers' beliefs often shape their practice in the classroom, and therefore should be considered (Enderle et al., 2014). Education research is full of examples where teachers have been on the receiving end of professional learning experiences where an expert delivers what they know to the teachers with a disregard for what teachers bring to the table (Dadds, 2014). At a minimum, PD should, according to Livneh & Livneh (1999) include opportunities for teachers to "(a) reflect on their practice and solve problems of practice collaboratively; (b) dialogue with colleagues; (c) develop a school culture that supports collaborative action versus individual development; (d) be based in actual work with students; (e) involve peer observation, coaching and feedback; and (f) be ongoing for the length of their career" (p. 92).

More thought could be given to the needs of the target audience when designing teacher PD. This may include considerations for incorporating teachers in the design of PD experiences. Teachers are drawn towards activities like collegial networks as they have some autonomy in their learning and can collaborate with and gain support from others (Lieberman & McLaughlin, 1992). By providing teachers, as adults, the opportunity to collaborate and reflect with their

peers, teachers are able to work together to connect their learning to the contexts of their classrooms (Kelly & Cherkowski, 2015). Even the most effective of PD will not connect with every teacher that participates, and as such, teachers need be provided the chance to select those opportunities that they feel will support their growth goals and needs (Avalos, 2011; Sample McMeeking et al., 2012).

While numerous characteristics of effective PD have been identified, additional research is needed to provide more of a consensus and synthesis around a set of characteristics (Wilson, 2013). Having a set of characteristics that can be included and measured in PD will strengthen the knowledge about what effective PD should include (Desimone, 2009). By more closely examining the characteristics of effective PD, and understanding teachers' perceptions regarding these characteristics, facilitators of PD can better align PD activities to the needs of the teachers being supported.

Chapter 3: Methodology

3.1 Introduction

For this study, a Q methodological survey was conducted. Q methodology is a robust and versatile mixed-methods approach that provides quantitative statistical data and supporting qualitative data of participants' perceptions. In this case, the use of Q methodology facilitated the opportunity to conduct a thorough analysis of teachers' subjective thoughts regarding the characteristics of effective PD. This chapter will describe the steps taken to select the items (statements) used in the survey and the methods used to collect the data. The research questions for the study were as follows:

1) What do science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on characteristics of effective professional development?
2) What connections exist between the characteristics of effective professional development science and mathematics teachers view as being important to their learning and the core adult learning principles?
3) To what extent can the continually growing list of characteristics of effective professional development be narrowed down to specific factors that can be considered when designing professional learning activities for science and mathematics teachers.

To begin answering these questions, it was important to consider which teachers to engage in this research study. Seeking out teachers with the necessary knowledge, in this case those with extensive experience participating in numerous and varied professional learning opportunities, became the target audience. The next step was determining how to approach the research literature and to tease out a select number of characteristics that were representative of all the identified characteristics of effective PD. Finally, a procedure for viewing the characteristics of

effective PD through the lens of adult learning theory was created in order to examine ways in which facilitators of professional learning can routinely design activities that consider the needs and experiences of teachers as adult learners.

This chapter will explore deeper the design of this research study. Of key importance are the decisions made related to the construction of the Q-survey. Additionally, the participant process and the data collection procedures will be detailed.

3.2 Q Methodology

Professional development studies have often focused on teacher satisfaction, attitude changes, and innovation shifts (Desimone, 2009). In developing these studies, researchers rely on many different ways to assess the quality of PD opportunities. These include surveys of teachers regarding their experiences with PD, classroom observation protocols and case studies of classroom teaching, and interviews (Garet et al., 2001; Heath et al., 2010). However, there have been calls to include more empirical methods of studying PD.

It appears that from a search of the literature, little is known about teachers' perceptions of the characteristics of effective PD. While multiple lists of characteristics have made their way into the body of literature, an understanding of the impacts of these characteristics on teacher learning is unknown (Garet et al., 2001). In considering an appropriate methodology to objectively analyze the subjective perceptions of teacher educators, it seems Q Methodology can provide statistical data, while including supporting qualitative data, to deliver a more complete analysis of teachers' perceptions of the characteristics of effective professional development.

Q Methodology was first introduced by William Stephenson in 1935 when he penned a letter in the journal *Nature* (Brown, 1980; Watts & Stenner, 2012. Stephenson was a mentee of

Spearman, the scholar who invented factor analysis (McKeown & Thomas, 2013; Watts & Stenner, 2012).

Factor analysis is a statistical method used to focus on traits. However, Stephenson adapted Spearman's method by what is described in the literature as inversion, now allowing for the factoring of persons instead of the factoring the traits (McKeown & Thomas, 2013; Watts & Stenner, 2012). In using this method, there exists the ability to examine human subjectivity in a quantitative way and to measure personal beliefs (Barnes et al., 2015; Brown, 1980).

In describing past uses of Q methodology, Zabala (2014) explains, "It is aimed at exploring the distinct perspectives, discourses, or decision-making styles within a group in order to address practical matters such as the acceptance of new policies and technology or increasing public participation" (Zabala, 2014, p. 163). While Q methodology has been used more regularly in social science research (e.g., psychology), it is applicable to many areas, and Stephenson's late theoretical work delved into quantum theory as a nod to his Ph.D. in physics (Newman & Ramlo, 2010; Stephenson, 1982; Watts & Stenner, 2012).

In practice, participants are required to force-rank a series of "self-referential" statements, thereby prioritizing their perceptions or beliefs on certain statements in relation to the other statements (Barnes et al., 2015, p. 142). Statements may be gathered through infinite ways including interviews, surveys, literature reviews, quotes, and Internet discussion boards, and reduced down to a representative sample of all the statements (Barnes et al., 2015; McKeown & Thomas, 2013). As mentioned, Q methodology then relies on an inverted method of factor analysis to identify groupings, or clusters, of individuals that are extracted in order to find individuals who rank items similarly (Dory et al., 2015). In simpler terms, Q methodologists are looking at correlations among people by how they responded to the set of statements (Danielson,

2009; Zabala, 2014). The ways in which these clusters form can then be interpreted using qualitative information collected from individuals through additional survey questions or semi-structured interviews (Collins & Liang, 2013; Dory et al., 2015).

Much stands to be learned regarding teachers' perceptions of the characteristics of effective professional development. In this study, through the use of Q methodology, teachers were provided with a carefully selected sample of characteristics that were pulled from the research literature, and teachers were asked to rank the statements from "most identify with" to "least identify with" in terms of their experiences participating in PD opportunities. Extracted factors provide a statistical representation of those select items that teachers feel most contribute to effective PD and their personal growth. Subsequent qualitative information collected from the teachers provides the rationale that helps explain the statistical analysis. Q methodology stands as a robust means for discovering and interpreting teachers' perceptions and beliefs that can aid in designing future effective PD (Still & Gordon, 2009).

3.3 Research Design

This research study employs the use of Q methodology to better understand teachers' perceptions of what are considered characteristics of effective PD. Due to its mixed-methods nature, this methodology can potentially satisfy those individuals that really want to see numerical data and statistical results, and yet, can help to frame and tell the story about what the data indicates (Watts & Stenner, 2005). This line of study deals with subjectivity, a place many researchers try to avoid. Certainly, this would seem like a slippery slope for science education. When considering the nature of science, McComas (2004) argued that science relies on empirical evidence. This poses a tall feat when considering the possibility of studying educators' random thoughts and ideas about a particular topic, and yet, Q methodology can provide quantitative data

for evaluation. Q methodology provides for the "systematic study" of subjectivity (Brown, 1993, pp. 94).

In designing the survey instrument for this study, there were several steps to go through. Paige & Morin (2016) provide a flow chart (see Figure 2) that highlights the normal process Q methodologists go through in creating a Q survey. The following subsections will detail the steps that were taken to create the Q survey for this study including the populating of the concourse, selection of the preliminary Q sample, the evaluation of the Q sample with experts, refinement of statements, and finally proceeding to the full Q study.

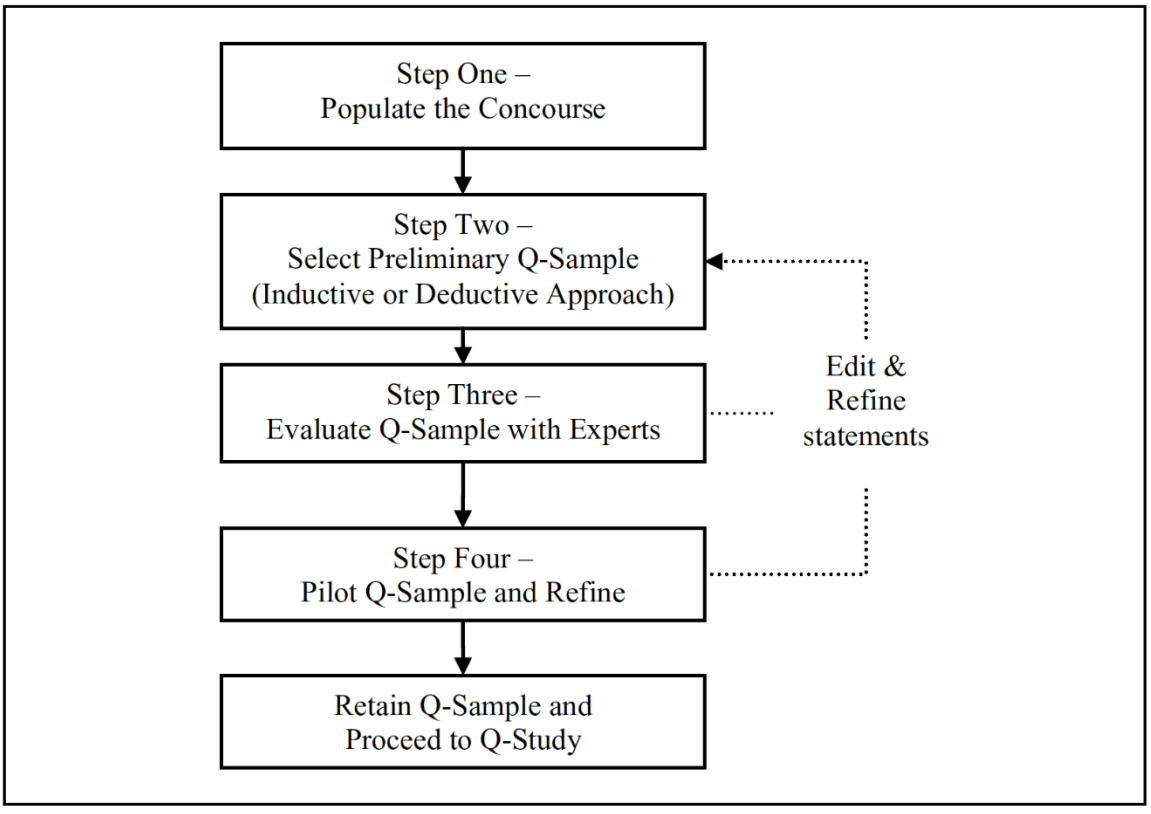

Figure 2: Q sample construction (Paige & Morin, 2016, pp. 99)

3.3.1 Concourse

A thorough literature review was completed on the characteristics of effective PD. The literature on PD is replete with ideas that have been identified as the characteristics, or features, or elements of effective PD. The issue, as someone who spends a lot of time planning and facilitating professional learning opportunities for teachers, is that there seems to be little evidence of efforts taken to ascertain teachers' feelings about these characteristics? What characteristics do teachers view as important for their personal growth? During that review of the literature, 139 features, or characteristics of effective PD were identified (see Appendix A), representing the concourse. In Q methodology, the concourse is the collection of characteristics (van Exel & de Graff, 2005) or population of statements or ideas (Watts and Stenner, 2012) for a particular topic or idea. Interestingly, the concourse does not need to be restricted to words, and may include art pieces, musical works, objects, etc. (Brown, 1993). When working with statements, these are meant to be common knowledge to the participants within the study (Stephenson, 1982).

Additionally, included in Appendix A after the population of statements is a list of statements from a Q methodological study that was completed by Brown & Militello (2016) that sought to survey principals on 34 aspects of "effective professional development" in order to "understand the perceptions principals have about elements of effective professional development and the role they play in facilitating the growth of teachers" (pp. 703).

The statements from the Brown & Militello study (2016) appear to overlap with some of the characteristics of effective PD found during the literature review for this study, and therefore several have been used in this study and cited with the literature they could possibly have been drawn from. However, since several of the statements are geared more towards ascertaining

principals' subjective thoughts on the characteristics of effective professional development, it was necessary to develop an instrument that was more appropriate for learning about teachers' perspectives of the characteristics of effective PD.

3.3.2 Q Sample Selection

Once the concourse was established from the literature review of the characteristics of effective PD, the process of creating the Q sample began. This begins the process of taking a large number of statements and condensing them down to a representative list of statements that attempts to capture the essence of the entire population of statements (McKeown & Thomas, 2013; Zabala, 2014). The Q sample (also referred to as the Q set) is typically 30-60 items in length (Newman & Ramlo, 2010). If the number of statements becomes too numerous, this poses a great demand on participants to adequately complete the sorting task associated with the Q study (Watts and Stenner, 2012). McKeown & Thomas (2013) state, "it's [Q sample] purpose is to provide a comprehensive but manageable representation of the concourse from which it is taken" (pp. 23).

In starting this process, the theoretical framework was brought in as a starting place to stratify the statements into the six Core Adult Learning Principles of Knowles et al. (2015) that were introduced in Figure 1 in Chapter 1 (p. 6). Using provisional coding and the six predetermined *codes* (the six Core Adult Learning Principles), all statements were organized under the six principles (Saldaña, 2012). In undergoing this process, a few statements were deemed similar enough that they were eliminated in this phase. From the 139 statements plus the 34 statements from Brown & Militello (2016), (total n=173), a total of 168 statements were stratified into six categories corresponding to the six Core Adult Learning Principles. Table 1 shows the number of statements placed within each of the six Principles. The percentage of

statements in each of the six categories is noted, with 23.21% within the *Need to Know* category which the category with the smallest percentage was *Learners' Self-Concept* at 13.10%.

Table 1: Initial stratification of statements into Core Adult Learning Principles (Knowles et al., 2015)

Label	Core Adult Learning Principle	Number of Statements	Percent
A	The Need to Know	39	23.21%
B	The Learners' Self-Concept	22	13.10%
C	Role of the Learners' Experiences	31	18.45%
D	Readiness to Learn	24	14.29%
E	Orientation to Learning	29	17.26%
F	Motivation	23	13.69%

Figure 3 provides an example of some of the statements that were sorted into three of the Core Adult Learning Principle categories (The Need to Know, The Learners' Self-Concept, Role of the Learners' Experiences) (Knowles et al., 2015).

After stratifying the population of statements into the six principles, the next step was to again code the information in the statements that were placed into the six *principle* categories. The statements in each category were considered separately from the other five categories. Inductive analysis of the statements was undertaken to begin to create a theory of how the statements relate to that particular adult learning principle and to one another (Williams & Toser, 2019). Open or *initial* coding was utilized and each statement was coded with a word or short phrase that would indicate the general meaning of that statement (Saldaña, 2012). Open coding was helpful in creating a structured sample that would be representative of the entire population of statements (McKeown & Thomas, 2013). In essence, the coding scheme was devised to continue the process of narrowing down the entire population of statements into a representative sample by beginning to identify particular themes to further classify the statements within each

A. The Need to Know (adults need to know why they need to learn something before undertaking to learn it. Facilitators need to help learners become aware of the need to know.)	**B. The Learners' Self-Concept** (responsible for their own decisions, for their own lives. Need to be seen/treated by others as being capable of self-directing. Create learning experiences in which adults are helped to make the transition from dependent to self-directing learners.)	**C. Role of the Learners' Experiences** (accumulated experiences. Wider range of individual differences than with a group of youths. Hence, experiential techniques that tap into experiences like group discussions, simulation exercises, problem-solving activities, case methods, laboratory methods—instead of transmittal.)
1. 9. choosing problem areas that have been identified by the learners through self-diagnostic procedures; 2. 16. that professional development not only involves changes in professional practice (actions), but also in practitioners' thinking about the how and why of that practice 3. 19. Having open dialogue with other teachers can have educational implications and purpose. 4. 26. Moreover, it is required to connect the lesson's subject with the trainees' needs and experiences. 5. 35. Receives coaching or mentoring. 6. 36.In-depth study of specific content concepts. 7. 39. Specific instructional approaches to content 8. 44. Phase 1 research provides evidence that high-quality professional development programs can help teachers deepen their knowledge and transform their teaching. 9. 45. Professional development programs that include an explicit focus on subject matter can help teachers develop these powerful understandings. 10. 53. Professional development that models instruction helps me to visualize how to implement my new learning in the classroom. 11. 55. We found that professional development focused on specific instructional practices increases teachers' use of those practices in the classroom.	1. 7. adults feel the need to learn and have input into what, why, and how they will learn. 2. 8. Having choice in the professional development that I participate in is beneficial to my practice. 3. 13. I am more committed to the professional development offerings where I am actively involved in the development by sharing my needs and problems. 4. 21. Experiencing learning is favored over being taught at. 5. 24. the role of the teacher (of Adults) is to engage in a process of mutual inquiry with them rather than to transmit his or her knowledge to them and then evaluate their conformity to it. 6. 27. To make their needs and expectations of the program known so they themselves can feel that they are participating in its formation. 7. 30. Creating and leading professional development helps to strengthen my understanding of a particular topic. 8. 32. Leads session during professional development. 9. 57. High-quality professional development includes providing teachers opportunities to take on leadership roles. 10. 66. Being treated as a colleague and professional by facilitators of professional is important to me. 11. 69. During professional development, opportunities to demonstrate learning in a	1. 1. Working with teachers from **different** disciplines helped to strengthen my learning in my individual discipline. 2. 4. Most of the in-service training or staff development that teachers are now exposed to is of a formal nature. Unconnected to classroom life, it is often a mélange of abstract ideas that pays little attention to the ongoing support of continuous learning and changed practices 3. 5. Working with teachers from my **same** discipline helped to strengthen my learning in my individual discipline. 4. 12. learners' previous experiences need to be taken into account in selecting methods and materials, in making presentations, and in helping learners to modify and transform the meanings and skills derived from their previous experiences 5. 18. Being part of a network of other like-minded professionals that are interested in learning leads to changes in my teaching practices. 6. 31. All teachers from school involved in professional development activities. 7. 47. A good facilitator that can establish a community around the work that is being done is crucial to the success of teacher learning in professional development.

Figure 3: Sample of the concourse stratified into the 6 Core Adult Learning Principles (Knowles et al., 2015).

of the six categories (Williams & Moser, 2019). In considering the Core Adult Learning Principle *Role of the Learner's Experiences,* such codes that were developed included *Time, Focus, Needs/Practice, Community, Value,* and *Ongoing*. Figure 4 provides an example of the document used to track the coding for the Principle *The Need to Know*.

	A	B
1	(Read these from Left-to-Right; Originals to Coded)	
2		Original
3	code	**A. The Need to Know** (adults need to know why they need to learn something before undertaking to learn it. Facilitators need to help learners become aware of the need to know)-23
4	focus	6. 9. Effective professional development focuses on problem areas that have been identified by the learners through self-diagnostic procedures .
5	theory	7. 16. Effective professional development not only involves changes in professional practice (actions), but also in practitioners' thinking about the how and why of that practice
6	other teachers	8. 19. Professional development that includes having open dialogue with other teachers can have educational implications and purpose.
7	theory	9. 26. Effective professional development connects the lesson's subject with the teachers' needs and experiences.
8	results	10. 44. Effective professional development programs can help teachers deepen their knowledge and transform their teaching.
9	focus	11. 45. Effective Professional development programs include an explicit focus on subject matter.
10	theory	12. 64. Effective professional development provides teachers with the opportunity to know both the subject matter and how students can best learn the subject.
11	focus	13. 75. Effective professional development provides curriculum materials are educative for teachers and students.
12	results	14. 82. Professional development that leads a teacher to know more (e.g., more subject matter, more educational theory, more pedagogy, more instructional strategies) and results in feelings of being
13	value	15. 84. Teacher professional development is no longer seen as a process of periodic "staff development".

Figure 4: Sample view of the document used to track open coding within each Core Adult Learning Principle

Once all statements in each of the six categories had been coded, it was possible to see the themes that emerged. From here, it was feasible to narrow down the overall pool of statements by eliminating statements that were similar in theme and where there seemed to be overlap from one statement to another. From the concourse, 44 statements were ultimately selected for the Q sample (see Table 2). The list as portrayed in this table is the final set of statements (the Q sample) that was used in this study. As will be described in the next section, the Q sample statements presented to experts for review and evaluation only required slight modifications in wording. However, all experts felt this list adequately captured the viewpoints in the body of research that includes characteristics of effective PD.

Table 2: Q set statements

Label	Statement
s1	Effective professional development involves visiting other schools.
s2	Effective professional development involves observing other teachers.
s3	Effective professional development is research-based and built upon theory.
s4	Effective professional development utilizes data from teachers' actual practice as the starting point for their critical and systematic reflection.
s5	A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.
s6	Effective Professional development programs include an explicit focus on specific content/subject matter.
s7	Effective professional development programs can help teachers deepen their knowledge and transform their teaching.
s8	Effective professional development requires participants to be involved in the planning, implementing, and evaluating of programs.
s9	Effective professional development includes follow-up and support for transfer of learning to the school or classroom.
s10	Effective professional development includes coaching from a peer or mentor.
s11	An effective element of professional development is providing constructive feedback on instructional practice.
s12	Effective professional development allows teachers to experience learning rather than being passive learners.
s13	Effective professional development includes teachers being treated as a colleague and professional by facilitators of professional development.
s14	Effective professional development includes providing teachers opportunities to take on leadership roles.
s15	Effective professional development includes opportunities for teachers to collaborate with experts.
s16	An effective element of professional development is to conduct differentiated sessions based on teachers' experience levels (e.g., pre-service teachers, new teachers, experienced teachers).
s17	Effective professional development focuses on pedagogy.
s18	A workshop facilitator who can establish a community around the work that is being done is crucial to the success of teacher learning within effective professional development.
s19	Active learning opportunities increase the effectiveness of professional development for teachers' instruction.
s20	Effective professional development that models instruction helps teachers to visualize how to implement their new learning in the classroom.
s21	Effective professional development includes time to collaborate with peers.
s22	Effective professional development requires establishing a collaborative culture among colleagues.
s23	Effective professional development allows teachers to balance personal life situations (e.g., child care, possible financial and family issues, other teaching responsibilities).
s24	During professional development, teachers will go through stages in the change process and will have different needs/require different supports at different stages.
s25	During effective professional development, teachers are committed to learning when the program's goals and objectives that are job related and perceived as being immediately useful.
s26	Effective professional development considers that teachers' physical and psychological comfort are taken into account.
s27	Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings.
s28	Activities within effective professional development are designed to help teachers better understand both what they teach and how students acquire specific content knowledge and skills.
s29	Professional development is more effective when it is part of the scheduled work day.
s30	Effective professional development includes learning that aligns curriculum to standards.
s31	Effective professional development that focuses on a particular teaching practice increases the likelihood of teachers' using that practice in their classroom

s32	Effective professional development includes an analysis of student work samples.
s33	Effective professional development includes providing opportunities for shared problem-solving.
s34	Effective professional development includes time for teachers to develop assessments.
s35	Effective professional development involves teachers' grappling with student thinking and considering the implications for instruction.
s36	Effective professional development includes resources and creative sessions similar to what is required by teachers in a classroom, so they can experience first what they are asked to put into practice.
s37	Effective professional development engages teachers in concrete tasks of teaching, assessment, observation, and reflection that illuminate the processes of learning and development.
s38	Professional development is more-effective if there is participation of teachers from the same school, department, and/or grade.
s39	While professional development programs are needed to provide an initial vision for change, networks of colleagues can be the motivating factor that sustains the work for change over time.
s40	Effective professional development links directly with day-to-day work in real schools and classrooms.
s41	Change/improvement strategies utilized within effective professional development are most effective when they are selected to meet teachers' needs.
s42	School administrators promote models of effective professional development that consider the organizational context, culture, and climate in which teachers work.
s43	Administrative (e.g., principals) support of reform is important for the success of effective professional development.
s44	Effective professional development utilizes activities that challenge teachers and promote their professional growth.

An analysis of the statements in the Q sample was conducted to determine the percentage of statements that remained from each of the six Core Adult Learning Principles designations. Overall, the percentages were relatively similar to the percentages represented in the concourse, with the exception of *The Needs to Know* which saw a significant drop in the percentage of statements included in the Q set. In the following table (Table 3), the breakdown of statements into the six *Principles* can be seen.

Table 3: Final stratification of statements into Core Adult Learning Principles (Knowles et al., 2015)

Label	Principle	Number of Statements	Percent
A	The Need to Know	6	13.64%
B	The Learners' Self-Concept	7	15.91%
C	Role of the Learners' Experiences	9	20.45%
D	Readiness to Learn	7	15.91%
E	Orientation to Learning	8	18.18%
F	Motivation	7	15.91%

3.3.3 Evaluate Q sample with experts

After the preliminary selection of the Q sample, as recommended my Paige & Morin (2016), experts in the field of education and professional development were consulted to review the statements in the Q sample. These individuals are colleagues who were very familiar with the research goals for this project. Additionally, they all have a great amount of experience that qualified them for the task of evaluating the Q sample to ensure the statements were representative of the views on this topic (Paige & Morin, 2016; Thomas & McKeown, 2013).

Table 4 provides a description of these participants. Please note, pseudonyms have been used in place of real names.

Name	**Expert Description**
Patricia Henry	Retired physics teacher with a PhD in science education. Currently serves as a science education consultant and PD provider for several school districts.
Roger James	Science education professor at a large comprehensive university in the northeast US. Holds a PhD in science education and is an active researcher.
Gina Case	Retired biology teacher and current science methods instructor for a large research institute in the northeast United States. Holds a PhD in science education. Facilitates PD for many teachers.
Quiana Reynolds	Former math teacher and school administrator in the northeast US. Currently serves as the Asst. Director for a large teacher PD provider.
Betsy Smith	Retired elementary teacher with a PhD in STEM Education. Currently serves as the education outreach coordinator for a large national government-supported non-profit and provides PD for STEM educators.
Penny Lerner	Retired chemistry teacher and current science methods instructor for a large research institute in the northeast United States. Holds a PhD in science education. Facilitates PD for many teachers.
Louann Miller	Former chemistry teacher and current district science supervisor in the northeast US. Holds a PhD in Curriculum and Instruction, and holds several leadership roles in several organizations for science teachers and administrators

Table 4: Expert evaluators that reviewed the provisional Q sample

Initially, all seven experts were sent the list of statements from the provisional Q sample. Considering each of their respective experiences in participating in and facilitating PD, they were each asked to review the statements and to determine whether they felt the statements adequately covered the important characteristics for effective PD. They were asked to suggest any additions

that could be considered for the list. Additionally, they were asked to consider the clarity of language for each statement and to suggest edits. A phone meeting was set up with each expert to discuss their thoughts. All seven experts felt that the statements were very representative of the characteristics of effective PD. No additions to the list of statements were suggested. For example, when Gina was asked whether or not anything was missing, she stated, “No, I don’t think so.” Betsy stated, “No, everything is well-represented.”

In the discussions with the experts, questions did arise regarding how teachers might define effective PD as they make their way through the statements. Penny asked, “Would teachers rank the statements differently if they were considering what is important in a one-off workshop vs. more long-term workshops.” Quiana questioned, “How will participants envision the definition of effective PD for teachers?” I asked the other experts whether or not an open-ended question should be added to Part B of the survey asking how the teachers would define effective PD would be valuable. All agreed.

3.3.4 Retain Q Sample and Proceed to Q Set

Working with the experts and having a chance to review the statements from the provisional Q sample with them helped to ensure this was a representative look at the characteristics of effective PD. Less a few grammatical and wording changes, the provisional Q sample was accepted for the study. Going forward, the established set of statements for the study will be referred to as the “Q set”. While overall, a great amount of work was spent in creating the Q set for this study, in the words of Watts & Stenner (2012), “The perfect Q set is probably a thing of fantasy and fiction” (p. 63).

It should be noted here that statements from the Q set were not piloted since a pilot study had been conducted previously with several of the statements and ideas contained in this Q set. This

research study is intended to be the grounding work for several future studies (to be discussed in Chapter 5). Appendix C provides the full Q set along with the source literature for each statement.

3.4 Participants in the Study

For this study, purposeful criterion sampling (Palinkas et al., 2013) was used to select participants for this study. The participants were composed of educators from across New York State that have completed four years of participation within the NYSMTP (www.suny.edu/masterteacher). There are many reasons why this population was selected for this study. In considering the research question for this study, these teachers have completed four years of intensive professional learning. They were required to complete a minimum of 50 hours of professional learning through the NYSMTP for each of the four years they were in the program (a total of 200 hours of professional learning over four years). This professional learning requirement was in addition to any district requirements for professional learning that they were responsible for completing and was in addition to any state requirements they might have had to maintain their teaching certification(s) in New York State. Therefore, they have all experienced and participated in a great and varied amount of PD recently.

In addition to these *master teachers* having participated in a significant amount of PD, there was also interest in looking specifically at STEM teachers in grades 7-12 as this is the population of teachers for which I facilitate STEM PD (i.e., purposeful sample) (Coyne, 1997). There is growing attention in the research literature on the integration of STEM education, yet many teachers are typically not trained on how to build integrated STEM lessons/units (Brown & Bogiages, 2019). Developing PD that is targeted and meets the needs of the teachers is necessary to ensure these teachers can develop integrated STEM activities on their own (Affouneh et al.,

2020). As such, all emeriti teachers of the NYSMTP meet this criterion. Additionally, all participants were expected to still be actively teaching.

To become a part of the NYSMTP, teachers must teach STEM courses (at least 60% of their teaching load must be in a STEM course), have a minimum of four-years teaching experience, and are high-performing within the teacher evaluation system in NYS. Teachers apply to be a part of the program and go through a rigorous application and selection process. Once in the program, teachers receive a stipend and, in addition to the professional learning they partake in, they are expected to serve as mentors for other STEM teachers across New York State.

The aim was to enroll 100 persons in this study, with a minimum response target of 30-50 participants. For a study such as this one, this range is considered large enough to encompass the scope of views on a given topic (McKeown & Thomas, 2013.) The request (Appendix B) to complete the survey was sent out to 147 individuals that were selected at random from the 553 emeriti teachers (150 initially, but the contact information for 3 individuals was unavailable). All were adolescence education (grades 7-12) Science, Mathematics, or Technology teachers. As can be seen in Table 5, the percentages of teachers from each of the subject areas in the entire population of teachers were 69.62% science, 28.57% mathematics, and 1.80% technology. Very similar percentages of science, mathematics, and technology teachers (72.79%, 25.17%, and 2.04%, respectively) composed the random sample drawn from the population. Respondents to the survey consisted of 69.76% science teachers and 30.23% mathematics teachers. No teachers that identified as technology teachers responded to the survey completion request.

Table 5: Participant Numbers

Label	Science	Math	Technology	Total
Entire population	n=385 69.62%	n=158 28.57%	n=10 1.80%	553
Sample of Population Survey Was Sent To	n=107 72.79%	n=37 25.17%	n=3 2.04%	147
Survey Respondents	n=30 69.76%	n=13 30.23%	n=0 0%	43

It is necessary to include a disclaimer here to minimize any appearance of a conflict of interest. The author of this study currently serves as the Assistant Director of the NYSMTP. However, the teachers selected for this study were drawn from the population of teachers (n=553) that have completed their tenure with the NYSMTP and therefore no longer have programmatic or reporting responsibilities to the program. In having helped to facilitate professional learning for this group of teachers, it is valuable to see the teachers' perspectives in regards to their professional learning experiences through the NYSMTP so that improvements can be made to professional learning opportunities facilitated through the program for current and future teachers enrolled in the program.

3.5 Data Collection

An online software package called HTMLQ was utilized to administer the survey instrument through a server hosted by the ITS (Information and Technology Service) at Syracuse University. Participating teachers were provided with a URL taking them to the site where the Q survey was set up. Each teacher was provided with a unique access code to enter the survey. Upon entry to the site, participants completed an online consent form and then began the survey instrument. The Q survey was divided into two parts: The Q sort and a supplemental online questionnaire.

For the Q sort, participating teachers were asked to sort the 44 statements comprising the Q set into 3 different piles or categories (Most Identify With, Neutral, Least Identify With) (see Figure 5). Once this task was completed, participants further refined their selections by placing their choices onto a grid (the Q sort distribution grid) (see Figure 6). Participants were asked to place the 44 statements on the grid, where a forced-choice distribution was used, from +5 to -5 (Watts & Stenner, 2012).

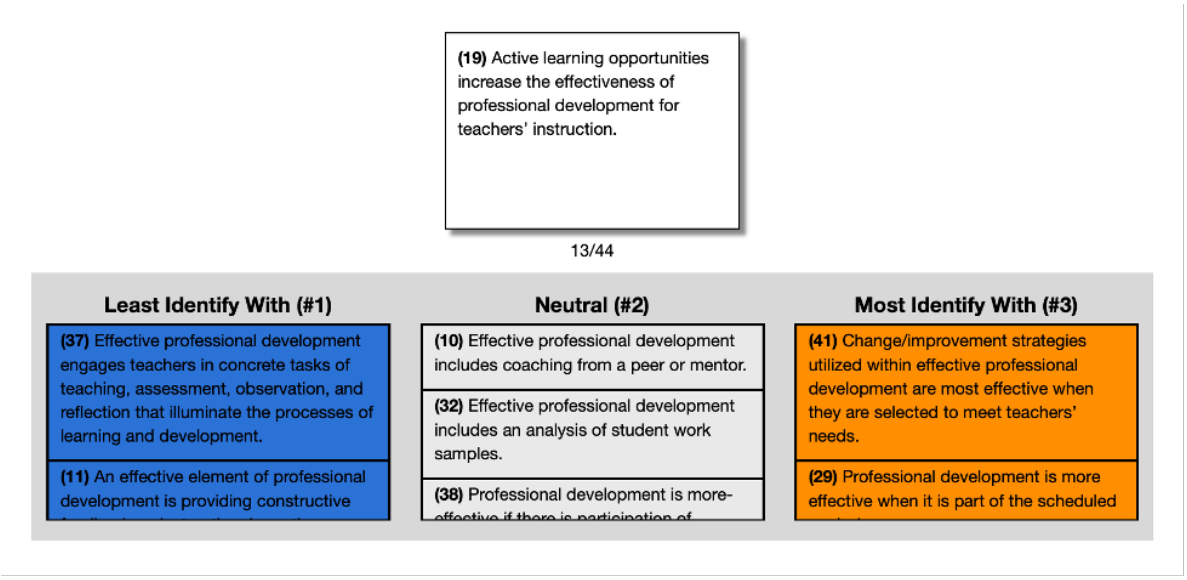

Figure 5: Provisional Ranking Categories

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
(2)										(2)
	(3)	(3)						(3)	(3)	
			(4)				(4)			
				(6)		(6)				
					(8)					

Least Identify With ⟵ ⟶ Most Identify With

Figure 6: Q-Sort Distribution Grid

To detail the sorting process, participating teachers were asked to first read through the statements in the *Most Identify With* pile and select the two statements that they most identify with as an important aspect of effective PD. Those statements would then be placed in the "+5" column (the order in which statements are placed within a column does not matter). This was repeated for the statements in the *Least Identify With* pile, but this time the statements were placed in the "-5" column. This process continued with the statements participants second most identified with and least identified with as important aspects of PD and placed them in the "+4" column and "-4" column (three statements for each), respectively. This procedure was continued for all statements in the "Most Identify With" and "Least Identify With" piles. Finally, the teachers were asked to read the statements in the "NEUTRAL" pile and arrange them in the remaining open boxes of the score sheet (which should have been close to the middle of the sheet). It is ok if participants run out of space and some of your neutral statements wind up under the "Most Identify With" or "Least Identify With" sides of the score sheet. Likewise, it is ok if some of the statements associated with "Most Identify With" and "Least Identify With" end up in the neutral column. The important piece in performing a Q sort is keeping the -5 to +5 rating in mind when placing statements on the Q sort grid so that they are sorted in the way the teachers identify with the statements.

Once teachers complete the Q sort, they were prompted to complete the supplemental questionnaire. The first important question asks participants to explain why they chose the 2 items with which they most identified with and to explain why they chose the 2 items with which they identified the least with (corresponding with the two items that fell under the +5 column and the two items that fell under the -5 column). Finally, teachers were asked to answer a set of

questions that provided descriptive data points regarding the participants. The full supplemental questionnaire is available for viewing in Appendix D.

3.6 Data Analysis

As mentioned previously, Q methodology is a mixed-methods approach used to study subjectivity in both a qualitative and quantitative manner (Newman & Ramlo, 2010). What is interesting and unique about this methodology is that it is designed to obtain individuals beliefs and to correlate viewpoints (Barnes et al., 2015,). In essence, the focus is not on the items of the study (in this case the statements in the Q set), but is on the participants who participate. In the words of the founder William Stephenson, "What is innovative…is the concept of universes or populations of statements as a primary source of statistical data in mental measurement, replacing that of populations of people" (Stephenson, 1980, p. 882). The goal then is to understand the perceptions people have on a topic from their own point of self-reference (McKeown & Thomas, 2013, p. 1).

The analysis of data in a Q methodological study is broken into three major components: (a) Factor Extraction; (b) Factor Rotation; (c) Factor Interpretation (Newman & Ramlo, 2010; Watts & Stenner, 2012). The first two components are heavily statistical in nature (McKeown & Thomas, 2013) while the third component involves a careful examination of the statements that comprise each factor. This third component also takes into account both the additional information provided in the responses to questions by the participants as well as demographic information about them (Brown, 1980; Watts & Stenner, 2012).

Due to the complex statistical nature of the factor extraction and rotation, the open and freely available statistical package *R* (https://www.r-project.org/about.html) was used for the quantitative analysis of data (Zabala, 2014b). *R* has a special package called *qmethod* that can be

downloaded to run the necessary analyses. While *R* does make the statistical calculations very easy, the challenge comes in determining the number of factors to extract and how to interpret the data (Watts & Stenner, 2012). Additionally, there are numerous decisions to be made on how to extract the factors and how to rotate them. Often, this means trying a variety of options and looking at the data output to determine when an appropriate result has been determined (Watts & Stenner, 2012). The code that was used to run the analysis for this study is provided in Appendix E. The following subsections will detail the decisions made for this particular study in analyzing the data.

3.6.1 Factor Extraction

The first step in the data analysis for a Q methodological study is factor extraction. Through factor extraction, the goal is to perform a data deduction to uncover patterns in the participants viewpoints (Newman & Ramlo, 2010; Zabala, 2014a). Factor extraction requires three separate steps: (a) correlation; (b) factor analysis or principal components analysis; and, (c) computation of factor scores.

For the analysis of data, researchers are interested in each of the sorts that participants made. In step 1 (correlation), a correlation matrix is created through the intercorrelation of each participant's Q sort with every other sort (Watts & Stenner, 2012). Normally, statistical packages for Q methodology will run a standard Pearson correlation (Zabala, 2014a). The Pearson correlation has been the preferred method in studies over time, and is said to provide similar results to other correlation methods (Brown, 1980). However, more researchers are starting to utilize a Spearman correlation instead as it is more appropriate for use with ordinal data as found in a Q sort (Alberts & Ankenmann, 2001; Danielson, 2009). A Spearman correlation is better for normal or continuous data (Alberts & Ankenmann, 2001; de Winter et al., 2016). One additional

advantage to using the Spearman correlation is that sometimes a greater amount of variability can be explained with fewer factors (Zabala, 2014a). Therefore, for this study, it was decided that a Spearman correlation would be used for the correlation of the teachers' Q sorts.

Once the correlation matrix was created, a decision was necessary for how to extract factors. Two methods are used in Q methodology: Principal Component Analysis (PCA) and Centroid Factor Analysis (CFA). Watts and Stenner (2012) argue that PCA is not actually a technique for factor analysis and therefore CFA should be considered as the principal method for factor extraction. Yet, the *qmethod* package for R does not provide for CFA as an option (Zabala, 2014), and PCA stands as a popular choice in most statistical packages (Akhtar-Danesh, 2017). The concern with PCA is that it only provides one mathematically best solution, unlike CFA which takes a more theoretical approach, allowing for extraction of factors in multiple ways (Watts & Stenner, 2012). Brown (1980) discussed how Stephenson, in pushing for the use of CFA, "was not merely revering the factor-analytic past, nor was he out of touch with contemporary developments; instead, he was seeking to advance a strategy of scientific inquiry for which the more "objective" procedures were inapplicable" (p. 236). While CFA seems to be preferred with many Q methodological researchers, it was determined for this study that PCA would be used since this is the factor extraction method of choice in R. Also, it seems it would take a great level of experience (beyond that of a novice doctoral student) to appropriately extract factors through CFA and determine if the results are better than those obtained through PCA.

The third step of factor extraction is computing factor scores. Through this process, the Q sorts that define each factor are flagged. The interpretation of factors is based on the factor scores (Brown, 1980). Factor scores represent "the degree to which each individual score

obtained through Q sorting rates high on statements that have high loadings on a factor" (Yoshizawa et al., 2016, p. 6284).

3.6.2 Factor Rotation

Prior to computing factor scores, it is advisable to go through the process of factor rotation. Through this process, "original factors are rotated about their origin to yield a simple structure and easily interpretable factors" (Akhtar-Danesh, 2017). Through factor rotation, the axes of the factors can be rotated in a 3-dimensional space in order to find the best fit between the variables and the latent factors, and to maximize the explained variance (Watts & Stenner, 2005). Rotation does not change the perspective or views imparted by the participants through their individual sorts or in relation to one another, but allows a shift in perspective (van Exel & de Graff, 2005). Essentially, a more meaningful pattern of factor loadings is achieved as factors are allowed to load more heavily on one factor, and minimizes loadings on other factors (Yoshizawa et al., 2016).

A cluster rotation method was chosen for this study as its oblique nature allows one to break the 90-degree relationship between factor axes, thereby allowing for greater flexibility in interpretation (Donatello & Roulades, 2020; Watts & Stenner, 2012). The reason for the use of cluster rotation over the popularized Varimax rotation is that "the "cluster" option does a "targeted rotation to a structure defined by the cluster representation of a varimax solution" (R Documentation: Principal Component Analysis, n.d.). This can help to maximize the amounts of variance explained across a smaller number of variables. Additionally, while many rotational methods seek to find a perfect and simple structure, this is not always possible (Yamamoto & Jennrich, 2013). As such, this method of rotation can "produce a simple and well-clustered structure of factor loadings" (Yamamoto & Jennrich, 2013, p. 489).

3.6.3 Factor Interpretation

According to McKeown and Brown (2013), factor interpretation is "the most challenging stage in Q methodology" (p. 14). While the data collected from the Q sort is quantitatively analyzed, the interpretation of that information is largely qualitative (Zabala, 2014). In a sense, the factor results are weaved together with the qualitative information collected in part B of the survey in a way that explains the data and helps to frame the meaning or viewpoint of each factor (Brown, 1993; Watts & Stenner, 2012). What was important to Stephenson was that factor interpretation requires a holistic view of all relevant viewpoints in order to objectively interpret the data (Stenner & Watts, 2012).

The first step was to create factor arrays for each of the factors in order to see the ranking in importance of each statement in an optimal sort for each factor (Watts & Stenner, 2012). The factor array is supposed to be the most representative of all individuals in that subgroup (Block, 1961). From there, it is important to note which items ranked high and low on that factor, and which factors ranked higher and lower on this factor when compared to any other factor in the study (Watts & Stenner, 2012). This is aided by the distinguishing statements table that can be generated. Another important table to generate is the consensus statement table. These are the statements that participants ranked similarly in value and therefore do not help to distinguish one factor from another (Watts & Stenner, 2012). Through an abductive process, the goal is to explain why the factor array is demonstrating a certain viewpoint (Watts & Stenner, 2012).

Additional data was used to help define the factors. For example, the demographic data that is collected helped in analyzing the data. As a precursor to the results, instead of analyzing the Q sorts of the science and mathematics teachers together, it became necessary to run the sorts for each subgroup separately. This may indicate a difference in how science and mathematics

teachers consider is important for their professional learning. Additional questions in Part B also help shed some light on the sorting decisions teachers made.

Helpful in the factor interpretation process was knowing how the teachers defined effective PD. Therefore, an open-ended response question was provided in the supplemental questionnaire where the teachers could input their definition. These responses were analyzed using open coding (Saldaña, 2015) to better understand the important ideas that were presented in the responses.

3.7 Summary

This chapter highlighted the implications for the use of Q methodology as the approach for understanding teachers' ideas and beliefs about the characteristics of effective PD. Through the processes and methodology explained, the possibility of narrowing down a large number of characteristics of effective PD to a small number of factors that are important to teachers' learning and growth poses an opportunity for PD facilitators. Q methodology makes this possible by leveraging the ability to quantitatively evaluate subjective viewpoints and to fully explain these quantitative results through supporting qualitative information, often in the words of the teachers themselves.

Chapter 4: Results of Q Analysis and Factor Interpretation

4.1 Introduction

This chapter presents the results and factor interpretations for the Q methodological study that was conducted to evaluate teachers' subjective views regarding the characteristics of effective PD. In analyzing the data, as discussed in Chapter 5 (Section 5.2.3), it was decided that the Q sorts for the science and mathematics teachers would be analyzed separately from each other, thereby separating the subject areas. As will be described in the next chapter, the Q sorts from the science and mathematics teachers were different enough such that by analyzing the groups separately, it was possible to evaluate the similarities and differences in which characteristics of effective PD the teachers most identified with. The *qmethod* package that is available for the R software package was used to perform factor extraction and factor rotation. Principal component analysis was used with a Spearman correlation and cluster rotation. Five factors emerged from the sorts of the science teachers and three factors emerged from the sorts of the mathematics teachers. Factor interpretation was completed with supporting information collected from the teachers in Part B of the survey instrument. Finally, the factors were evaluated using the Core Adult Learning Principles (Knowles et al., 2015) to determine if overlap exists in what teachers value about PD and what is known about adult learning.

4.2 Analysis and interpretation of results for participating science teachers

In considering the science teachers that completed the Q sort, a total of 30 Q sorts were intercorrelated and analyzed. A total of five factors were extracted and rotated, representing

Table 6: Science teacher participants' demographic information and factor loadings

ID	Gender	Race	Age (years)	Grade Level	Years Teaching	District Type	Subject	Factor Loadings 1	2	3	4	5
12-53220	Female	White	55-64	9-12	26+	Suburban	Science	0.60***				
12-21320	Female	White	55-64	9-12	11-15	Suburban	Science	0.65***				
12-00820	Male	White	55-64	9-12	26+	Suburban	Science	0.49***				
12-53520	Female	White	55-64	6-8	26+	Rural	Science	0.78***				
12-47920	Female	White	35-44	6-8	16-20	Suburban	Science	0.79***				
12-43920	Male	White	35-44	9-12	11-15	Rural	Science	0.55***				
12-29120	Female	White	45-54	6-8	21-25	Urban	Science	0.49***				
12-30820	Female	White	35-44	6-8	11-15	Suburban	Science	0.43***				
12-28420	Female	White	55-64	6-8	26+	Suburban	Science	0.49***				
12-20320	Male	White	35-44	9-12	16-20	Suburban	Science		0.56***			
12-05420	Female	White	35-44	9-12	11-15	Suburban	Science		0.79***			
12-01420	Female	White	55-64	9-12	26+	Urban	Science		0.76***			
12-46920	Female	White	45-54	9-12	11-15	Rural	Science		0.64***			
12-35120	Male	White	55-64	9-12	26+	Rural	Science		0.61***			
12-31120	Male	White	35-44	9-12	21-25	Rural	Science		0.50***			
12-40420	Female	White	45-54	9-12	16-20	Suburban	Science		0.56***			
12-02620	Male	White	35-44	9-12	16-20	Rural	Science			0.52***		
12-42720	Female	White	55-64	9-12	26+	Rural	Science			0.56***		
12-04220	Female	White	45-54	6-8	26+	Rural	Science			0.58***		
12-27620	Male	White	35-44	9-12	21-25	Rural	Science			0.68***		
12-31620	Male	White	45-54	9-12	21-25	Rural	Science			0.58***		
12-06920	Female	White	45-54	9-12	21-25	Suburban	Science				0.54***	
12-39057	Female	White	35-44	6-8	16-20	Rural	Science				0.71***	
12-50520	Female	White	35-44	9-12	21-25	Urban	Science				0.54***	
12-04720	Male	White	45-54	9-12	26+	Suburban	Science				0.69***	
12-15720	Female	White	35-44	9-12	16-20	Suburban	Science					0.56***
12-08820	Female	White	55-64	6-8	26+	Suburban	Science					0.70***
12-44720	Male	White/Black	35-44	6-8	16-20	Urban	Science					0.63***

Note: *** p<.001

52.03% of the study variance. Of the 30 participants, 28 of 30 loaded significantly on one of the five factors. Table 6 provides demographic information on the teacher participants and their corresponding factor loadings. Factor loadings were all of 0.38 or above and statistically significant at the $p < 0.001$ level (Watts & Stenner, 2012). Each factor is described by the model ideal factor array created through factor analysis as a composite of the Q sorts for that factor (McKeown & Thomas, 2013). Additional questions from part B of the research instrument helped to clarify the thinking of the teachers' rankings.

A decision had to be made about how many factors should be extracted. To make this decision, a series of extractions were made to determine what would make the most sense statistically. According to Watts and Stenner, a first step is to "accept those factors that have two or more significant factor loadings following extraction" (p. 107). In looking at Table 7 below, this would mean eliminating n=7. Factors with Eigenvalues greater than 1 are deemed significant as well (Thomas & McKeown, 2013), which all factor loadings met as shown.

Table 7: Summary of factor characteristics: extraction analysis information for science teachers

Science	**Loadings per Each Factor**				
Factor	**n=7**	**n=6**	**n=5**	**n=4**	**n=3**
Factor 1	4	6	9	9	11
Factor 2	5	5	7	7	10
Factor 3	5	3	5	7	8
Factor 4	3	4	4	4	x
Factor 5	2	2	3	x	x
Factor 6	1	3	x	x	x
Factor 7	2	x	x	x	x
Q Sorts	22	23	28	27	29
Eigenvalue Range	1.98-3.78	2.13-3.69	2.22-4.29	2.46-4.57	3.07-4.35
% Explained Variance	62.14	58.09	52.03	45.87	39.08

Another determining factor was the number of Q sorts that loaded when extracting n number of factors and viewing the explained variance, which, according to Zabala (2016), "are approximate indicators of the strength of each perspective and of the proportion of the opinions they explain" (p. 168). Explained variance of 35-40% (or more) is acceptable in a study like this (Watts & Stenner, 2012, p. 105). In considering this, n=5 gave us a large number of Q sorts that loaded on the factor, and had a percentage of explained variance that was well above the 35-40% threshold. For all these reasons, five factors were selected for interpretation.

4.2.1 Factor 1 (Science): A focus on activities that model actual practice

Factor 1 had an Eigenvalue of 4.29, and nine participants loaded significantly on Factor 1, representing 30.0% of the participants and 14.29% of the study variance. Figure 7 shows the model factor array. In looking at the science teacher participants that loaded significantly on Factor 1, seven identified as female and two identified as male. Five were middle school teachers (grades 6-8), and four were high school teachers (grades 9-12). In terms of teaching experience, three teachers had 11-15 years of experience, one teacher had 16-20 years of experience, one teacher had 21-25 years of experience, and four teachers had 26+ years of experience. The teachers worked predominately in suburban schools (n=6) while two worked in rural districts and one in an urban district. Table 8 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

This factor speaks to the idea that professional learning that provides teachers with active learning opportunities is valuable to their practice (s19: +5). These active learning opportunities, however, need to be presented in a way that utilize resources similar to what teachers would have and how the teachers would present ideas to their students, (s36: +4). In a way, this is modeling what teachers should be implementing new ideas in their classrooms. In thinking about their

growth and learning, teachers are concerned with how students think and learn, and therefore activities should promote practice in working directly with students (s28: +5; s35: +4). These activities should challenge teachers so that they are learning something new (s44: +4).

Least Identify With					**Neutral**					**Most Identify With**
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
1	31	4	2	6	15	7	5	3	35	19
14	34	29	11	8	21	9	39	12	36	28
	38	29	32	10	24	16	40	13	44	
			42	17	25	18	41			
				23	26	20				
				37	27	22				
					33					
					43					

Figure 7: Factor Array (Model Sort) for Factor 1 (Science)

Table 8: Factor 1 (Science) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s19	Active learning opportunities increase the effectiveness of professional development for teachers' instruction.
5	s28	Activities within effective professional development are designed to help teachers better understand both what they teach and how students acquire specific content knowledge and skills.
4	s35	Effective professional development involves teachers' grappling with student thinking and considering the implications for instruction.
4	s36	Effective professional development includes resources and creative sessions similar to what is required by teachers in a classroom, so they can experience first what they are asked to put into practice.
4	s44	Effective professional development utilizes activities that challenge teachers and promote their professional growth.
-4	s31	Effective professional development that focuses on a particular teaching practice increases the likelihood of teachers' using that practice in their classroom
-4	s34	Effective professional development includes time for teachers to develop assessments.
-4	s38	Professional development is more-effective if there is participation of teachers from the same school, department, and/or grade.
-5	s1	Effective professional development involves visiting other schools.
-5	s14	Effective professional development includes providing teachers opportunities to take on leadership roles.

The participants on this factor stressed the importance of the value of new learning, being challenged, and receiving resources to support instruction. Participant 12-43920 spoke of (s3)

and the need for PD to "continuously update what and how we teach based on the latest research available." However, participant 12-30820 stressed about (s40) "If it doesn't have an application to what I'm doing, then no *bueno*." For participant 12-29120, (s19) meant to her that "Teachers need to be able to apply/implement what they have learned and be able to evaluate what they did in order to improve on it." Along similar thinking, the value for participant 12-21320 wasn't necessarily an idea or concept that could be implemented, but resources. She shared about (s36), "I feel the most impact from PD when I leave a session with materials that I can immediately implement."

Participants on this factor also spoke of student learning as a means for their PD participation. Emphasizing this idea, participant 12-21320 said about PD (s5), "it is very important that the time I put in is not just 'nice to know' but information I 'need to know' so that it will have a positive impact on the success of my specific group of students." Participant 12-53520 said about (s28) that "If the PD is designed to help teachers with their instructional skills, then a review of how students acquire knowledge and skills is important." Similarly, participant 12-28420 said about (s35), "Understanding how students think is critical to finding ways to teach them." Participant 12-29120 shared about (s7) that, "True PD will enhance a teacher's content knowledge and help them to broaden their instruction. Ultimately, this will lead to better student understanding in the long run."

The participants on this factor ranked low statements s31, s34, s38, s1, and s14. Teachers on this factor don't rank in importance the need to visit other schools (s1: -5). Participant 12-21320 stated about (s1) that she had been a part of PD sessions in other schools and that:

> the strategies the other school is using looks encouraging. But then there is the obstacle of selling it to your home school and colleagues as the culture of each school varies so

much that the strategies don't always transfer from school to school.

Teachers on this factor also didn't necessarily value highly the need for PD to include teachers from the same district or grade level (s38: -4). Participant 12-28420 stated about (s38) "Although there are times where learning with your colleagues is good it is sometimes better to step out and see what others are doing." Participant 12-21320 said about the same statement, "Sometimes when colleagues from the same school work together at PD there can be some resistance to working to modify instruction or some pessimism seeps in. It also becomes cliquey sometimes."

Statement 14 dealt with teachers taking on leadership roles through PD participation (s14: -5). For two participants, this was scored low by them and appeared on this factor. Participant 12-00820 said, "This can be valuable, but I've had plenty of effective PD that didn't involve teachers taking on leadership roles." Participant 12-53520 said, "I see it [leadership role} as an extra burden placed on the teacher group. In some ways, I can see that the leadership opportunity may be a good thing but, in practice, I believe that it reflects administrations deflection of responsibility."

Ranked low on this factor by three participants was (s29), which talks about PD being scheduled during the day. Participant 12-29120 stated, "I don't believe that time of day is a deciding factor. Ideally, making sure there is enough time to process the information presented is more important." Participant 12-53220 considered logistical issues in her response regarding PD during the day and said, "it requires me to make substitute plans so that my students have effective instruction during my absence. This costs me so much time to plan and sometimes the substitute teacher does not follow the plans." She continued that PD during the summer is best as this is "time for me to really learn, relax, collaborate, and take the time to incorporate in my lessons for the next year." Participant 12-00820 spoke of his experience with PD scheduled

during the day saying, “Generally, though, when it's been part of the work day the session involved some generic PD that left me feeling I'd have been better off working with students, grading, and/or preparing lessons.” In all these responses, the hassle of planning to be out of the classroom, and the lack of time to dedicate to learning and then implementation are perhaps reasons to avoid PD activities during the school day.

In conclusion, participants that loaded on Factor 1 favor learning that models the type of teaching activities they should be using in their classrooms, and the use of resources that can help promote success. Additionally, through these activities and opportunities for learning, teachers are quite concerned with student thinking and learning, and are participating in PD to perhaps meet the needs of their students.

4.2.2 Factor 2 (Science): Collaboration with peers

Factor 2 had an Eigenvalue of 3.44, and seven participants loaded significantly on Factor 2, representing 23.3% of the participants and 11.48% of the study variance. Figure 8 shows the model factor array. In looking at the science teacher participants that loaded significantly on Factor 2, four identified as female and three identified as male. All seven were high school teachers (grades 9-12). In terms of teaching experience, two teachers had 11-15 years of experience, two teachers had 16-20 years of experience, one teacher had 21-25 years of experience, and two teachers had 26+ years of experience. The teachers were split fairly evenly in the type of district they worked in with three in suburban districts and three in rural districts. One teacher worked in a rural district. Table 9 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

Of high importance to the teachers that loaded on this factor is time to collaborate with peers during PD activities (s21: +5) and the establishing of a collaborative culture amongst colleagues

in PD opportunities (s22: +4) Teachers seek a link to the day-to-day work that they do in their schools and classrooms as well (s40: +4), and teachers are seeking to deepen their knowledge to transform their teaching (s7: +4). Teachers on this factor also want to be engaged in active learning experiences rather than being passive learners (s12: +5).

Least Identify With					Neutral				Most Identify With	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
23	16	1	2	6	4	5	11	33	7	12
29	26	34	3	9	13	15	19	37	22	21
	38	43	8	10	14	17	35	39	40	
			42	18	25	28	44			
				20	27	31				
				24	30	36				
					32					
					41					

Figure 8: Factor Array (Model Sort) for Factor 2 (Science)

Table 9: Factor 2 (Science) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s12	Effective professional development allows teachers to experience learning rather than being passive learners.
5	s21	Effective professional development includes time to collaborate with peers.
4	s7	Effective professional development programs can help teachers deepen their knowledge and transform their teaching.
4	s22	Effective professional development requires establishing a collaborative culture among colleagues.
4	s40	Effective professional development links directly with day-to-day work in real schools and classrooms.
-4	s16	An effective element of professional development is to conduct differentiated sessions based on teachers' experience levels (e.g., pre-service teachers, new teachers, experienced teachers).
-4	s26	Effective professional development considers that teachers' physical and psychological comfort are taken into account.
-4	s38	Professional development is more-effective if there is participation of teachers from the same school, department, and/or grade.
-5	s23	Effective professional development allows teachers to balance personal life situations (e.g., child care, possible financial and family issues, other teaching responsibilities).
-5	s29	Professional development is more effective when it is part of the scheduled work day.

As noted, collaboration with other teachers is valued by the teachers that loaded on this factor. Participant 12-35120 stated about (s39):

> Probably the single biggest reason that the New York State Master Teacher program was able to provide such exceptional professional development was the ability to form networks of elite level colleagues all working towards a common goal. Having regular contacts with people you had professional development with is crucial for the long term implementation into one's teaching practices. Without this, these experiences often go to the back burner and are quickly forgotten.

Similarly, participant 12-40420 spoke about the time she had spent collaborating with other teachers:

> The most benefit that actually translated into improvement for me in the classroom was the physics professional learning team because we were collaborating together and sharing experiences. It was in this group that we discovered some common misconceptions or misuses of terms and were able to help each other develop or improve labs, terminology or simply lessons.

Also, of importance is that teachers want to be actively engaged in learning that deepens their content and pedagogical knowledge. Participant 12-01420 shared about (s7), “As a result of numerous, high quality, professional development experiences that I had, I was able to continually deepen my content knowledge, increase my pedagogical tool box and become a more effective teacher.” Similarly, participant 12-40420 said about (s6), “If we want to teach more effectively, then the emphasis needs to be on what we teach and not some nebulous theory.” The active engagement component was noted by participant 12-31120, and he said about (s12):

> Even teachers (like myself) have a hard time paying attention in meetings that involve us being passive...Checking email or grading papers has become common during PD, and

even those that are not distracted to that level are daydreaming and thinking of other worries.

Agreement with being engaged in PD activities was seen in the response by participant 12-01420 regarding (s19), “I strongly believe that being actively involved in the learning process greatly improves the level of comprehension and increases the ease of implementation.”

The statements that were ranked low on this factor were s29, s23, s38, s26, and s16. Ranking at -5 on this factor was (s29), which suggests PD should be part of the scheduled work day. Four participants on this factor ranked the statement in that position. For participant 12-31120, he said, “I do not want to miss time with my students. I understand the idea or thinking that '9-5 I am in work mode', but I do not agree with it.” Participant 12-01420 had a very similar reason, and she said, 12-01420, “I have found that most science teachers (myself included) do not want to give up a day of instruction with their students for professional development.” However, the thinking regarding this statement and when PD should be offered was a little different for participant 12-20320 as he said, “I think professional development is something that can be effective at any time, including on weekends and during the summer. Because teachers are constantly reflecting, I think professional development can be effective all the time.” Participant 12-35120 had yet another thought about PD during the day saying, “Absolutely not, unless it is a faculty development day fully devoted to that PD. After school professional development opportunities are rarely effective. The block of time is too short, and the levels of motivation are usually waning at that time.”

Statement (s23), which discusses effective PD as allowing teachers to balance personal life situations was ranked at -5 by three teachers on this factor. Participant 12-46920 mentioned the need for teachers to work PD in around their schedules, but she indicated that this isn’t a “valid

measure for the quality of professional development." Participant 12-20320 spoke of how he tries to limit the crossover of his work and life responsibilities in saying:

> When I think of effective professional development, I am thinking about my job and not on other aspects of my life as much. And because I feel that effective professional development can be conducted any day of the week and after school hours, I think it can be scheduled around other personal situations.

Participant 12-35120 felt that "There are many resources available to faculty to deal with these issues. Don't waste my professional time dealing with issues that some of my colleagues should be able to resolve on their own." Statement (s26) is perhaps related to this statement and the sentiment of the participants on this factor as well since it considers addressing teachers' physical and psychological needs during PD activities.

Statement (s38) focuses on PD participation with colleagues from the same school, department or grade. One teacher, participant 12-05420, who is from a small suburban school, ranked this statement at -5 and said:

> Because I work in a small school, I benefit more from working with teachers from other schools because there is only one other teacher in my district who teaches the same subject that I do…Although I love my department and the team I work with and I learn a lot from them, I also feel professional development quality is improved by different perspectives from other schools.

In summary, factor 2 considers the importance of peer collaborations as an important part of effective PD. Additionally, teachers want to be actively engaged in the deep learning of new content and pedagogical skills and knowledge. What does not resonate with teachers on this factor is PD that is actually a part of the school day as it takes them away from their students.

Further, there is a feeling that one's personal life should not interfere with their job and therefore related ideas of trying to build PD around a teacher's needs may not necessarily be an indicator of effective PD.

4.2.3 Factor 3 (Science): Continuous/Long-term learning with follow-up support

Factor 3 had an Eigenvalue of 3.26, and five participants loaded significantly on Factor 3, representing 16.6% of the participants and 10.87% of the study variance. Figure 9 shows the model factor array. In looking at the science teacher participants that loaded significantly on Factor 3, two identified as female and three identified as male. One was a middle school teacher (grades 6-8), and four were high school teachers (grades 9-12). In terms of teaching experience, one teacher had 16-20 years of experience, two teachers had 21-25 years of experience, and two teachers had 26+ years of experience. The teachers all worked in rural districts. Table 10 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

This factor calls for PD to be continuous and long-term (s27: +5). Such PD programs can help teachers deepen their knowledge and transform their teaching (s7: +4). As part of the continuous and long-term nature called for, effective PD includes opportunities for follow-up for teachers and support as they implement new skills and knowledge in the classroom (s9: +4). Teachers are expecting that new knowledge being introduced is applicable to their work (s5: +5), and that it is grounded in the subject area of the participants (s6: +4).

Least Identify With					Neutral				Most Identify With	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
1	14	2	4	11	15	8	12	3	6	5
29	26	18	10	16	17	13	19	25	7	27
	42	36	33	21	22	20	28	44	9	
			38	23	24	31	40			
				32	30	34				
				39	35	41				
					37					
					43					

Figure 9: Factor Array (Model Sort) for Factor 3 (Science)

Table 10: Factor 3 (Science) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s5	A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.
5	s27	Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings.
4	s6	Effective Professional development programs include an explicit focus on specific content/subject matter.
4	s7	Effective professional development programs can help teachers deepen their knowledge and transform their teaching.
4	s9	Effective professional development includes follow-up and support for transfer of learning to the school or classroom.
-4	s14	Effective professional development includes providing teachers opportunities to take on leadership roles.
-4	s26	Effective professional development considers that teachers' physical and psychological comfort are taken into account.
-4	s42	School administrators promote models of effective professional development that consider the organizational context, culture, and climate in which teachers work.
-5	s1	Effective professional development involves visiting other schools.
-5	s29	Professional development is more effective when it is part of the scheduled work day.

Three out of the five teachers that loaded on this factor spoke specifically to the idea of the importance of continuous and long-term professional learning. Participant 12-31620 stated about (s27):

> Studies have shown we learn over time. The one time profession [*sic*] development offering can and will spark interest and enthusiasm for a concept. This can quickly fade if not allowed to work on the PD or collaborate with others. Teachers also need to ask

> questions that will arise during the stages of development, implementation, and refinement. Not having these opportunities leave teachers questioning the value of changing and if the work putting into new ideas are worth it.

Participant 12-42720 focused on the logistics of implementation in response to (s27), saying:

> Many PD opportunities are interesting or appear to be workable but when tried in a classroom, don't flow well. Having the chance to work out those kinks and try again is invaluable and something that is not available with one time PD.

Statement (s9) is closely related to (s27) in the sense that the follow-up support that can come from continuous and ongoing learning is beneficial. As such, it appears participant 12-31620 ranked this statement as +5 as well. When discussing this statement, he said:

> Having professional development which is not continuous and lacks follow through does not allow for teachers to improve. Too many times we attend good professional development classes and then are given no time to work on the material or there are no follow session [*sic*] to ask questions or develop with others. Schools fall in a trap of always implementing a new idea, but never develop, implement, and refine these ideas in the classroom. Teachers are left to trial and error and guesses on what works well and what does not. Teachers will fall back into their comfort zones and abandon trying new ideas/trainings due to a lack of follow through and a sense of apathy by the district.

He seems to attribute some of the issues of implementation, fairly or unfairly, to district leadership. Yet, there is also the indication that it tends to be easy for teachers to slip back into what they know and what they are comfortable with.

Teachers on this factor are also looking for the content of PD activities to be directly applicable to the content in their classrooms. Participant 12-04220 said about (s30):

> Teachers will attend professional development that directly aligns with the standards they teach. I seek out workshops on topics that I am being asked to teach that I may not feel confident with because of a lack of knowledge. I am also more apt to implement the strategies shown during the workshop if they align with my curriculum.

Having that connection to the curriculum was also important to participant 12-42720, and she said about (s7): “It is much more empowering to both the student and the teacher when a teacher can say, well, I'm not certain but I think, from what I gathered from the last PD I went to that...” Yet, participant 12-02620 works in a rural district and indicated this is not the experience he has had. He said about (s6), “Most often in small rural schools such as mine professional development is focused on 'one size fits all' programming.”

Ranking low on factor three were statements s29, s1, s42, s26, and s14. Statement (s1) suggests a characteristic of effective PD involves teachers visiting other schools. Three participating teachers on this factor ranked this statement at -5. Participant 12-42720 said, “In small, rural school districts, this is simply not feasible. Between travel time and having to be out of your own classroom, visiting another school to observe instruction or to collaborate with another teacher is just not worth it.” Participant 12-04220 expressed it was unnecessary to visit another school. She said, “I have attended workshops with teachers from other schools. I do not need to be in their school watching how they implement the workshop ideas.” Participant 12-31620 said visiting other schools has not been effective for him:

> Over the years visiting other schools has not been effective. Each school is unique in its culture, student body, teacher student interactions, administration support, physical layout, supplies, technology resources, and so on. What works in one school will not perfectly work in another. Having the opportunity to talk with teachers and having

> discussions is effective on what did and did not work. Observing others was time consuming and I rather have spent the time in talking with colleagues to pick their brains.

Statement 29 suggests that PD should occur during the school day. However, two teachers on this factor disagree with this. Participant 12-04220 said:

> If an opportunity to attend a workshop on a topic that is very important to me happens to fall on an evening or weekend, I will try to attend. I am always seeking out new professional development opportunities no matter the time of the year.

Participant 12-31620 shared the challenge of participating in PD activities during the day, especially if it is necessary to return to the classroom after:

> When taking professional development, it is taxing on the brain. I am mentally exhausted afterwards or am enthusiastic over the material and need time to digest and work through what we just covered. Having part of the work day isn't always productive if I have to go back and teach after a session. My mind is focused on the material and it is difficult to try and get back into teaching mode. When I do teach I lose sight on the material that we covered in the PD. When I have a chance to reflect later I find myself not making strong connections to my teaching.

Participant 12-27620 ranked (s26) at -5 as well and shared, “Personally I am not overly concerned with 'physical and psychological comfort.' If the PD is worthwhile then I will do it. If it isn't then I will be miserable regardless of my personal state going into the PD.” Participant 12-42720 shared her concerns regarding (s42) and the decisions administrators make in selecting PD programs. She said, “My experience has been that often administrators go with whatever program is popular or was presented at the last administrators meeting that they attended.”

In summary, factor 3 emphasizes the importance of continuous and ongoing PD that includes support for teachers as they implement their new learning and skills back in their districts. Also stressed through this factor is that new learning should be applicable to the teachers' classroom and should not be generic *one-size-fits-all*. Teachers do value connecting with teachers outside their school, but feel they do not need to visit other teachers' schools to make that happen.

4.2.4 Factor 4 (Science): Immediate/useful connections to current classroom work

Factor 4 had an Eigenvalue of 2.39, and four participants loaded significantly on Factor 4, representing 13.3% of the participants and 7.98% of the study variance. Figure 10 shows the model factor array. In looking at the science teacher participants that loaded significantly on Factor 4, three identified as female and one identified as male. One was a middle school teacher (grades 6-8), and three were high school teachers (grades 9-12). In terms of teaching experience, one teacher had 16-20 years of experience, two teachers had 21-25 years of experience, and one teacher had 26+ years of experience. Two teachers worked in suburban schools, one worked in a rural district, and one worked in an urban district. Table 11 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

Least Identify With					**Neutral**				**Most Identify With**	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
3	29	1	2	11	6	4	9	14	5	23
10	30	8	16	20	12	7	18	22	13	25
	32	34	17	27	15	21	24	41	26	
			19	35	31	38	28			
				43	33	40				
				44	36	42				
					37					
					39					

Figure 10: Factor Array (Model Sort) for Factor 4 (Science)

Table 11: Factor 4 (Science) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s23	Effective professional development allows teachers to balance personal life situations (e.g., child care, possible financial and family issues, other teaching responsibilities).
5	s25	During effective professional development, teachers are committed to learning when the program's goals and objectives that are job related and perceived as being immediately useful.
4	s5	A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.
4	s13	Effective professional development includes teachers being treated as a colleague and professional by facilitators of professional development.
4	s26	Effective professional development considers that teachers' physical and psychological comfort are taken into account.
-4	s29	Professional development is more effective when it is part of the scheduled work day.
-4	s30	Effective professional development includes learning that aligns curriculum to standards.
-4	s32	Effective professional development includes an analysis of student work samples.
-5	s3	Effective professional development is research-based and built upon theory.
-5	s10	Effective professional development includes coaching from a peer or mentor.

The characteristic of effective PD that is the focus of factor 4 is the immediate and useful connections of new skills and knowledge to current classroom work (s25: +5; s5: +4). Another important aspect on this factor is that teachers are respected as colleagues by facilitators of PD (s13: +4). In this respect is a recognition that teachers are busy individuals and are regularly needing to fit PD in around their work schedule and home life (s23: +5). Relatedly, it is important teachers physical and psychological comfort are taken into consideration by the PD facilitator (s26: +4).

Four participants loaded on this factor, but only two teachers commented on the reasoning for their +5 selections. Two out of four teachers ranked (s25) of highest importance to them. While participant 12-39057 did not comment, participant 12-04720 stated, "from a practicality standpoint, teachers want and choose professional development that is perceived as being most relevant and useful." Relatedly, he said about (s41), "I think most teachers place great value on professional development that is practical and meets immediate needs." Participant 12-50520 spoke more to the value of collaborations that occur from PD. About (s22), she said, "Having a

collaborative culture means teachers get the chance to talk about their craft and hear what works/doesn't work for others." About (s21), she said, "I learn the most when I have time to interact and collaborate with my peers, even if they don't teach the same subject."

The statements scoring low on factor four were s10, s3, s32, s30, s29, and s28. One idea that seems to emerge as being not as important to the teachers that loaded on this factor is subject content does not need to be the basis for all PD. Participant 12-50520 said about (s6) "I would much rather focus on pedagogy and even hear what teachers at other grade levels do (especially primary teachers - they are rock stars!)." Often content is tied to curriculum and standards. Participant 12-39057 said about (s30):

> Not all professional development is related to the curriculum and the standards. Some of the best PD I have attended focused more on relationships and mutual goal setting. This includes relationships between colleagues and also relationship building with students. This has nothing to do with WHAT is being taught but rather HOW we become effective educators.

This statement seems to be related to the low ranking provided to (s3) which is about how effective PD is research-based and built upon theory. In some ways there is nothing in her response that would call upon theory, but seems grounded in how the PD is facilitated to focus on collaboration and relationship building.

Similar to factor 3, also scoring low on this factor is the idea that PD should be part of the school day. In discussing (s29), participant said about PD that it is "most effective when it works for the attendee. Some of my favorite PD events were off-site for several days where there was limited technology. There is something to be said for 'unplugging' and focusing on the tasks at hand." Limiting the influence of administration on what PD teachers need was the focus for

participant 12-50520. She said about (s42), “I don't need my administration to promote my growth as a teacher. I just need them to not be in my way.” Participant 12-04720 suggested that teachers do not necessarily need to be involved in the planning and implementation of PD, saying about (s8), “I do not think that that professional development effectiveness need be predicated on [*sic*] planning/implementing, and evaluating programs.”

In summary, teachers that loaded on this factor are seeking new skills and knowledge through PD that is immediately applicable in their classrooms. Teachers also need to know that any changes to their normal teaching practice that is being promoted will be valuable to their current work. Teachers on this factor are not locked into PD that is just content-focused, but are open to exploring pedagogy. They are also seeking collaboration with other teachers when participating in PD.

4.2.5 Factor 5 (Science): Teacher participation in creation and implementation

Factor 5 had an Eigenvalue of 2.39, and three participants loaded significantly on Factor 5, representing 10% of the participants and 7.41% of the study variance. Figure 11 shows the model factor array. In looking at the science teacher participants that loaded significantly on Factor 5, two identified as female and one identified as male. Two were middle school teachers (grades 6-8), and one was a high school teacher (grades 9-12). In terms of teaching experience, two teachers had 16-20 years of experience and one teacher had 26+ years of experience. Two teachers worked in suburban schools and one worked in an urban district. Table 12 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

In considering factor 5, teachers that loaded on this factor value being involved in the creation and implementation of PD (s8: +4). In unpacking this idea, it should be understood what

these teachers value includes teachers being treated as a colleague and professional by facilitators of professional development (s13: +4). In the design of PD, teachers on this factor did suggest PD should be a part of the scheduled work day (s29, +5), as compared to factors 1-3 where it was ranked much lower by participants. Also important is the connection made in the PD activities to the day-to-day work that takes place in a teacher's classroom (s40: +4). Evaluation is an important part of what teachers do with students, and therefore providing a space for the development of assessments ranked highly on this factor (s34: +5).

Least Identify With					**Neutral**				**Most Identify With**	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
10	9	4	5	7	12	1	14	2	8	29
11	30	27	23	16	15	3	17	6	13	34
	39	43	25	18	20	22	19	44	40	
			33	35	21	28	26			
			41	42	24	32				
					31	38				
					36					
					37					

Figure 11: Factor Array (Model Sort) for Factor 5 (Science)

Table 12: Factor 5 (Science) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s29	Professional development is more effective when it is part of the scheduled work day.
5	s34	Effective professional development includes time for teachers to develop assessments.
4	s8	Effective professional development requires participants to be involved in the planning, implementing, and evaluating of programs.
4	s13	Effective professional development includes teachers being treated as a colleague and professional by facilitators of professional development.
4	s40	Effective professional development links directly with day-to-day work in real schools and classrooms.
-4	s9	Effective professional development includes follow-up and support for transfer of learning to the school or classroom.
-4	s30	Effective professional development includes learning that aligns curriculum to standards.
-4	s39	While professional development programs are needed to provide an initial vision for change, networks of colleagues can be the motivating factor that sustains the work for change over time.
-5	s10	Effective professional development includes coaching from a peer or mentor.
-5	s11	An effective element of professional development is providing constructive feedback on instructional practice.

In seeking to understand the perspective of the teachers that loaded on this factor, participant 12-08820 suggested that teachers seek leadership roles. She said about (s14):

> In the classroom we strive to let our students be the "teachers," so too the most learning will occur when teachers can lead teachers. This fosters "becoming an expert" so as to share and then leads that teacher into a broad exploration of new ideas for him/her to implement in their own classroom.

Teachers wanting to take on this additional responsibility would need to be involved additionally to help lead PD. Participant 12-15720 said about this statement that it is, "Especially valuable for experienced teachers to stay current on what the research says about teaching today's students. Things change and you need to stay current. Especially in science where even the content changes based on new ideas." Similarly, participant 12-44720 said about (s40), "PD that is the newest fad is often irrelevant to the daily issues that I face. When PD is focused on at hand issues, in my building, I am much more likely to care." In considering the appropriate time to offer PD, participant 12-44720 suggested about (s29) that, "Asking teachers to stay late or do PD [*sic*] virtual on our own personal time is unacceptable, yet often that is how administration thinks PD should be done."

On factor 5, the statements that ranked low were s11, s10, 39, s30, and s9. Statement (s10) and Statement (s11) could be viewed as somewhat related as (s10) involves teachers getting coaching from a peer or mentor and (s11) is the providing of constructive feedback on instruction, which could be from a peer of mentor. Participant 12-08820 stated about (s10), "Sometimes if this is a forced opportunity teachers can take offense to someone else identifying their instructional strategies. Having said that, this could be productive of the peer coached is

properly coached." Yet it would seem that outside perspective could be helpful for some teachers. For example, participant 12-15720 said about (s29):

> I am a Physics teacher and there is only 1 other Physics teacher in my building. Any content specific PD is just the two of us. It is hard to just do PD with the same person all the time and he is not the same type of teacher as me. I value out of school PD where I can collaborate with other Physics teachers who think like me.

Collaborating with other physics teachers, in this case, could successfully look like a mentor-mentee relationship. 12-15720 (s34) said:

> I think PD should focus on teaching strategies or other things that can help my students in the classroom. Assessments just give me data on how the students are doing and how I am doing. I should focus on PD that getting me better at the teaching part.

In summary, factor 5 suggests that involving teachers in the planning and implementation of PD is important. Also, connecting this PD work to what teachers do in their classrooms is ranked highly on this factor. However, teachers on this factor do not seem keen on participating in models of PD where they are coached or mentored by someone else. Instead, they want to be viewed as colleagues or equals of the facilitators.

4.3 Analysis and Interpretation of Results for Participating Mathematics Teachers

In considering the mathematics teachers that completed the Q sort, a total of 13 Q sorts were intercorrelated and analyzed. A total of three factors were extracted and rotated, representing 52.48% of the study variance. Of the 13 participants, all 13 loaded significantly on one of the three factors. Table 13 provides demographic information on the teacher participants and their corresponding factor loadings. Factor loadings were all of 0.38 or above and statistically significant at the $p < 0.001$ level (Watts & Stenner, 2012). Each factor is described by the model

factor array created through factor analysis. Additional questions from part B of the research instrument for teachers helped to clarify the thinking on their rankings.

Table 13: Mathematics teacher participants' demographic information and factor loadings

ID	Gender	Race	Age (yrs)	Grade Level	Years Teaching	District Type	Subject	Factor Loadings 1	2	3
12-32920	Female	White	45-54	9-12	26+	Rural	Math	0.67***		
12-49220	Female	White	45-54	9-12	16-20	Rural	Math	0.69***		
12-39920	Female	White	35-44	9-12	21-25	Urban	Math	0.67***		
12-31920	Male	White	35-44	9-12	11-15	Suburban	Math	0.48***		
12-02820	Female	White	35-44	9-12	11-15	Rural	Math	0.67***		
12-05720	Female	White	35-44	9-12	11-15	Rural	Math	0.61***		
12-15320	Male	White	35-44	9-12	11-15	Suburban	Math		0.73***	
12-22420	Male	White	35-44	9-12	11-15	Suburban	Math		0.76***	
12-02020	Female	White	45-54	9-12	21-25	Suburban	Math		0.35***	
12-18620	Female	White	35-44	9-12	21-25	Suburban	Math		0.58***	
12-03520	Male	White	35-44	9-12	6-10	Suburban	Math			0.51***
12-01320	Male	White	45-54	9-12	21-25	Suburban	Math			0.72***
12-04420	Female	White	35-44	6-8	16-20	Suburban	Math			0.87***

Note: *** p<.001

Again, a decision had to be made about how many factors should be extracted. To make this decision, a series of extractions were made to determine what would make the most sense statistically. In looking at Table 14 below, n=7, n=6, and n=5 were all rejected as some factors did not meet the minimum threshold of 2 loadings on every factor (Watts and Stenner, 2012). In looking at the Eigenvalues for n=4, the lowest is 1.42 which is on the very low end of significance (Thomas & McKeown, 2013). Ultimately the extraction of three factors was selected for this study. Given the smaller sample size of mathematics teachers in this study, this made sense. One rule of thumb, but not a hard-and-fast rule is to have one factor for every 6 to 8 participants (Watts and Stenner, 2012). While this is a suggestion from Watts and Stenner (2012), they also share:

> Small numbers of participants can still be used to generate very big, and very meaningful, conclusions, even if generalizing to populations of people is precluded, and this can be a great advantage to Q methodology. (p74).

Table 14: Summary of factor characteristics: extraction analysis information for mathematics teachers

Math	**Loadings per Each Factor**				
Factor	n=7	n=6	n=5	n=4	n=3
Factor 1	3	4	4	6	6
Factor 2	2	3	3	2	4
Factor 3	2	2	3	3	3
Factor 4	2	2	2	2	x
Factor 5	2	1	1	x	x
Factor 6	1	1	x	x	x
Factor 7	1	x	x	x	x
Q-Sorts	13	13	13	13	13
Eigenvalue Range	2.07-1.10	2.32-1.10	2.30-1.15	2.92-1.42	2.63-2.03
% Explained Variance	80.42	73.76	67.07	61.15	52.48

4.3.1 Factor 1 (Mathematics): Engagement in active learning

Factor 1 had an Eigenvalue of 2.63, and six participants loaded significantly on Factor 1, representing 46.2% of the participants and 20.20% of the study variance. Figure 12 shows the model factor array. In looking at the mathematics teacher participants that loaded significantly on Factor 1, five identified as female and one identified as male. All six were high school teachers (grades 9-12). In terms of teaching experience, three teachers had 11-15 years of experience, one teacher had 16-20 years of experience, one teacher had 21-25 years of experience, and one teacher had 26+ years of experience. Four teachers worked in rural districts, one worked in a suburban district, and one worked in an urban district. Table 15 provides a look at the five

highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

When considering the mathematics teachers that participated in this study, factor one speaks to the need to engage teachers in active learning. Participants do not want to be passive learners (s12: +5). They suggest that active learning increases the effectiveness of PD that is targeted towards teacher practice and instruction (s19: +4). This is done through the use of activities that challenge teachers' current knowledge and promotes their growth (s44: +5). Related to active engagement during PD, having the opportunity to experience what they are to put into practice through the use of resources is preferred (s36: +4).

Engagement in active learning that models best practices for teaching may be what teachers seek. Participant 12-05720 said about statement (s20):

> When I feel like I am participating in a learning strategy I am usually aware of how I can (or sometimes can't) implement it directly in the classroom. If I have to think about how to apply the concept or the strategy into my classroom, and especially if that time isn't provided during the session I probably won't use it at all. When I see it modeled then I am instantly start [*sic*] to think about how it would apply to my classroom.

It seems when teaching strategies are modeled and teachers can participate as learners, the lift to implementing these new strategies may not be as large for teachers. Similarly, participant 12-39920 about (s36) and her experience, "It's nice to model how the program works. As a teacher you have a better idea of how to implement it yourself." Participant 12-05720 considered the time involved with needing to implement something new. She said about (s36), "Time is limited. If I have to spend time thinking about how to apply it, then I am less likely to use it." Participant 12-49220 focused more on being challenged and shared about (s27), "In-depth

introduction that poses a challenge to teachers' ways of thinking about teaching and learning while teachers are in the role of learner."

Least Identify With					Neutral				Most Identify With	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
29	1	26	10	3	4	7	21	9	19	12
34	2	32	14	6	5	13	28	25	24	44
	42	38	15	18	8	20	37	35	36	
			23	22	11	27	40			
				41	16	30				
				43	17	33				
					31					
					39					

Figure 12: Factor Array (Model Sort) for Factor 1 (Math)

Table 15: Factor 1 (Math) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s12	Effective professional development allows teachers to experience learning rather than being passive learners.
5	s44	Effective professional development utilizes activities that challenge teachers and promote their professional growth.
4	s19	Active learning opportunities increase the effectiveness of professional development for teachers' instruction.
4	s24	During professional development, teachers will go through stages in the change process and will have different needs/require different supports at different stages.
4	s36	Effective professional development includes resources and creative sessions similar to what is required by teachers in a classroom, so they can experience first what they are asked to put into practice.
-4	s1	Effective professional development involves visiting other schools.
-4	s2	Effective professional development involves observing other teachers.
-4	s42	School administrators promote models of effective professional development that consider the organizational context, culture, and climate in which teachers work.
-5	s29	Professional development is more effective when it is part of the scheduled work day.
-5	s34	Effective professional development includes time for teachers to develop assessments.

Experiencing learning was also important to participant 12-02820. She said about (s12) and engaging in active instead of passive learning, "This was especially helpful for me in learning the Common Core Learning Standards. Diving into curriculum and seeing how students would view content and practicing the presentation of material with peers." Participant 12-39920 discussed

about (s8) how active learning can be supported in others ways. She shared, “when you feel like a part of the process it makes it more meaningful and valuable in the classroom. Especially in the planning stages.” Yet, teachers want to be challenged in their learning and ideas. Participant 12-49220 said about (s44), “My own experiences and my graduate level research indicates that when my own (or teachers') ideas about learning are challenged by professional development, the result is a motivation to change thinking and practice about teaching and learning.” However, what one teacher needs (or what challenges one teacher) may not be the same for others. Participant 12-32920 posed in her response to high ranking of (s6):

> What helps an elementary teacher will probably not be relevant to my area of teaching and vice versa. A lot of the professional development that has been effective in the past was subject-specific - what is important to a math teacher might not be a priority to an English teacher and vice versa.

So, active engagement in learning and learning which allows teachers to experience learning as their students would seems beneficial.

For the first factor (mathematics), the statements that were scored low included s 34, s29, s42, s2, and s1. Statement (s34) was ranked at -5 by two participants on this factor. While this statement is about taking time during PD to develop assessments during a PD session, I think for these two participants, there is a broader concern about what teachers should not (and should) be creating during a PD session. Participant 12-49220 shared:

> I develop assessments on a regular basis as part of my teaching duties. I want to grow in PD sessions and take that information and experience back to the work I already do. I want my PD to change how I think about things, give me examples and experiences that

> inform my work as a teacher. I do not create/develop materials on demand well, and would prefer to do those things on my own time as part of my regular process.

Participant 12-39920 seemed to share that assessment development might be premature when learning something new that hasn't been taught. She shared, "Not everything is assessment based and for me it's hard to create the assessment if it's a new unit I'm teaching before I actually teach it."

For participants on this factor, creating assessments are not the only thing that is not preferred. Participant12-32920 expressed similar sentiments regarding PD needing to be aligned with curriculum. She said about (s30):

> Usually, the professional development that has been most useful to me in the past has nothing to do with aligning curriculum to standards - I'm more interested in best practices, ways to improve student learning, technology updates (especially in this pandemic), how to help my students learn, ways to motivate students.

Participants on this factor also do not favor the idea of PD happening during the school day. Participant 12-49220 shared regarding (s29) and having to prepare for being out of the classroom and being away from her students. She said, "I am constantly comparing the worth of the PD to the worth of my presence in my classroom. The PD is judged within the framework of 'I left my students for this...'." Similarly, participant 12-05720 described that, "A lot of my most valuable professional development sessions have been outside of the scheduled work day."

The way in which teachers work with other teachers was addressed by some teachers. Participant 12-39920 said about (s1), "It's not always necessary to see how other schools do things. Each school is unique and has it's [*sic*] own personality." In terms of observing other teachers, participant 12-02820 has relegated this to novice teachers by saying about (s2), "I think

this would be helpful for new and preservice teachers, but not necessarily veteran teachers." Peer coaching, another way in which educators can collaborate is considered in the literature to be an effective characteristic of PD. Yet, participant 12-02820 said about (s10), "I've found the most effective professional development to involve collaboration with peers, and I would not necessarily consider this to be coaching."

In summary, factor 1 speaks to the notion that teachers want to be engaged and active, not just passive learners. They want learning to model the types of practices they should be using with their students. They are not necessarily looking to do mundane activities they can do on their own time like the writing of assessments. There is also the desire to branch away from content-specific PD aligned to curriculum and standards. Finally, teachers want to have choice in PD, and that choice includes timing. PD is wanted outside of the school day to limit the interruptions with students.

4.3.2 Factor 2 (Mathematics): New learning is applicable to current practice

Factor 2 had an Eigenvalue of 2.63, and four participants loaded significantly on Factor 2, representing 30.8% of the participants and 16.66% of the study variance. Figure 13 shows the model factor array. In looking at the mathematics teacher participants that loaded significantly on Factor 2, two identified as female and two identified as male. All four were high school teachers (grades 9-12). In terms of teaching experience, two teachers had 11-15 years of experience, and two teachers had 16-20 years of experience. All four teachers worked in suburban districts. Table 16 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

Teachers that loaded on factor 2 seem to be interested in new knowledge and skills that directly translate to what they are already doing in their classrooms (s40: +4). Teachers do want

to know that the change being promoted through PD is of value to their work (s5: +5). Ranked high on this factor is the idea that data from teachers' actual practice is used as the starting place for influencing the direction of growth (s4, +4). In some ways, teachers from the same departments and/or grade level experience similar needs based on their situation, and therefore by learning together, they can impact change more broadly in a school (s38, +4). Teachers on this factor also prefer to be engaged and active learners (s12, +5).

Least Identify With					**Neutral**				**Most Identify With**	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
10	1	32	11	2	6	20	9	18	4	5
29	3	34	23	7	16	21	13	39	38	12
	15	44	25	8	17	28	19	41	40	
			30	14	26	31	22			
				24	27	36				
				42	33	37				
					35					
					43					

Figure 13: Factor Array (Model Sort) for Factor 2 (Math)

Table 16: Factor 2 (Math) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s5	A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.
5	s12	Effective professional development allows teachers to experience learning rather than being passive learners.
4	s4	Effective professional development utilizes data from teachers' actual practice as the starting point for their critical and systematic reflection.
4	s38	Professional development is more-effective if there is participation of teachers from the same school, department, and/or grade.
4	s40	Effective professional development links directly with day-to-day work in real schools and classrooms.
-4	s1	Effective professional development involves visiting other schools.
-4	s3	Effective professional development is research-based and built upon theory.
-4	s15	Effective professional development includes opportunities for teachers to collaborate with experts.
-5	s10	Effective professional development includes coaching from a peer or mentor.
-5	s29	Professional development is more effective when it is part of the scheduled work day.

Four teachers loaded on factor 2, three of the four provided comments for the reasoning behind their +5 choices. An important characteristic for the teachers on this factor is that there is demonstrated value inherent in the PD opportunity, as mentioned in (s5). For participant 12-15320, this seems to be counter to the experiences he has had with district-sponsored PD. He said:

> If I don't believe what is being presented to me is useful, I won't try to use it. Teacher buy-in is crucial...and it's hard for all teachers to buy in to the 'same thing.' This is why I believe that Superintendent Conference Days are almost always ineffective...because what is being presented doesn't always apply to everyone in the room.

Similarly, participant 12-22420 shared similarly:

> If a teacher does not buy into what is being discussed in the PD, they are likely to be disengaged and there is little room for learning. One of the first steps to a successful PD is to help participants understand why this is important and how it will help them become a more effective teacher. Unless teachers are convinced of the value of the PD, they are likely just biding their time to get PD hours, and hence the PD is not truly effective.

Arguably along the same lines that the PD is valuable to teachers' work, statement (s40) mentions as a characteristic of effective PD that there needs to be direct link to the day-to-day classroom work of teachers. Participant 12-15320 said, "If I see what is being presented as something I could use daily in my classroom (and would make what I currently do better), then I will use it." For participant12-22420, this connection is based on information from their classroom, which corresponds to (s4). He said:

> Just like as teachers we try to activate students' prior knowledge before teaching them something new, so that they have a firm foundation to build upon, it is important to view

> PD sessions in the same way. I don't necessarily agree with the word 'data' -- it's not like you have to show them Regents [state testing] scores, etc. -- but I think you need to start with areas that are actually applicable to teachers' practice. Otherwise, teachers are not likely to buy into the PD, and they will also not have a way to act upon their learning--hence the PD is not effective.

Scoring low on factor two for the mathematics teachers were statements s29, s10, s15, s3, and s1. Three out of four of the teachers that loaded on this factor scored (s29) at a -5. This statement is about PD being scheduled during the work day. In some sense, there is a logistical challenge posed by PD that is scheduled during the work day. For others, the timing of PD doesn't seem to influence whether or not a teacher determines if the PD is effective. Participant 12-15320 said:

> If I have a choice, I would never choose to attend a professional development session that would take me away from my actual students. Making sub plans and 'cleaning up mistakes' that subs make is way more stressful to me than just missing the professional development all together. If professional development is meaningful, I will make time to attend.

For participant 12-22420, he indicated that the best PD he engaged in, "was after the school day. So I don't think this is particularly relevant-- it is much more important that the PD is facilitated well and includes participants who are willing to engage with the learning." The view for participant 12-02020 was, "If you are eager for change and PD is offered you seize the moment."

Statement (s1) was ranked at -5 by two out of four participants on this factor. This statement suggests visiting other schools as an effective characteristic of PD. Participant 12-22420 shared:

> I think visiting other schools is quite hard to do, and while that could be an aspect of an effective PD, I don't see why it would be a factor in making it effective. The facilitation is more important-- a badly facilitated PD at a different school just means you had to travel far for a bad PD!

Perhaps his statement was in thinking that you would go to another school for PD instead of perhaps observing how teachers in that school are implementing teaching in a different manner. Participant 12-18620 shared how this would make sense only if the two schools had similar makeups. She said:

> Visiting other schools would only seem appropriate if the schools have a very similar student population, climate and leadership team. Just because something works in one school does not imply that it would work elsewhere. However, there are exceptions, for example, if a school is planning to implement a new literacy program, visiting a school that has that program in place may beneficial.

Another statement to get a low ranking by a participant on this factor was (s30) which suggests PD includes learning that aligns curriculum to standards. The view of participant 12-18620 on this statement was, “I think that aligning curriculum and standards is the job of a curriculum writing team. I see this as different from PD, which should focus on developing and implementing pedagogical strategies that will engage children and encourage them to grow.”

In summary, factor 2 calls for new learning to be applicable to current classroom practice. Teachers want to know that new learning they undertake will align with their current practice. This can be supported by evaluating what teachers are doing and using data from current practice to information PD instruction. For teachers loading on this factor, PD should not be scheduled during the work day due to logistical challenges of being out of the classroom, and for the simple

fact that timing should not be a determining factor as to the effectiveness of PD. Interest in how another district implements learning is of importance when similar demographics and culture exist between schools or when similar learning programs are being utilized.

4.3.3 Factor 3 (Mathematics): Support through change

Factor 3 had an Eigenvalue of 2.63, and three participants loaded significantly on Factor 3, representing 23.1% of the participants and 15.62% of the study variance. Figure 14 shows the model factor array. In looking at the mathematics teacher participants that loaded significantly on Factor 3, one identified as female and two identified as male. One was a middle school teacher (grades 6-8) and two were high school teachers (grades 9-12). In terms of teaching experience, one teacher had 6-10 years of experience, one teacher had 16-20 years of experience, and one teacher had 21-25 years of experience. All three teachers worked in suburban districts. Table 17 provides a look at the five highest and lowest scoring statements for this factor (+5 and +4 statements and -5 and -4 statements).

Factor 3 calls for support of teachers as they implement change in their classrooms. Part of that support is ensuring that the personal needs of teachers are met first. PD that is linked directly to the day-to-day work of teachers helps to deepen their knowledge and to transform their teaching (s40: +4; s7: +4). Yet, not all teachers that attend PD are in the same place professionally. As teachers proceed through PD, they will go through stages in the change process and will have different needs and/or require different supports at different stages (s24: +5). Support can be provided by other teachers when time for collaboration is factored into the design of PD (s21: +4). Support extends to the personal needs of teachers as well as they are trying to balance their work and professional lives, and PD can be an added responsibility (s23: +5).

Least Identify With					Neutral				Most Identify With	
-5	**-4**	**-3**	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**
4	16	6	26	1	3	2	12	20	7	23
42	33	8	30	17	10	5	19	28	21	24
	34	32	38	31	11	9	25	39	40	
			44	35	14	13	36			
				37	15	29				
				41	18	43				
					22					
					27					

Figure 14: Factor Array (Model Sort) for Factor 3 (Math)

Table 17: Factor 3 (Math) Most Identify With and Least Identify With statements

Score	Label	Statement
5	s23	Effective professional development allows teachers to balance personal life situations (e.g., child care, possible financial and family issues, other teaching responsibilities).
5	s24	During professional development, teachers will go through stages in the change process and will have different needs/require different supports at different stages.
4	s7	Effective professional development programs can help teachers deepen their knowledge and transform their teaching.
4	s21	Effective professional development includes time to collaborate with peers.
4	s40	Effective professional development links directly with day-to-day work in real schools and classrooms.
-4	s16	An effective element of professional development is to conduct differentiated sessions based on teachers' experience levels (e.g., pre-service teachers, new teachers, experienced teachers).
-4	s33	Effective professional development includes providing opportunities for shared problem-solving.
-4	s34	Effective professional development includes time for teachers to develop assessments.
-5	s4	Effective professional development utilizes data from teachers' actual practice as the starting point for their critical and systematic reflection.
-5	s42	School administrators promote models of effective professional development that consider the organizational context, culture, and climate in which teachers work.

The connection to the day-to-day work of PD and its immediate usefulness (s25) was the focus for participant 12-01320. He stated:

> When PD is seen as immediately useful, there is a higher chance of it becoming 'sticky.' The learning that we do at workshops (or things we read) that we cannot immediately put into practice is less likely to be retrieved later. It will have become forgotten and irrelevant.

Implementing new learning can be boosted by the support of colleagues. Participant 12-03520 said about (s39), “Having the support of colleagues who are trying to implement new strategies can serve as a sounding board, source of inspiration, and someone to push you forward if you hit a wall when trying to implement new strategies.”

Teachers have needs both in and out of the classroom that require support and consideration by facilitators of PD. Participant 12-01320 said about (s5), “Motivation is a tremendous factor in learning. We are busy professionals. Everything we invest time in is at the expense of something else we are not doing.” This aspect of teachers being busy resonated with participant 12-04420 as well as she said about (s23):

> Teachers can only be stretched so thin. It is important for them to feel they can devote all of themselves to those in front of them at the time, without guilt looming over them that they are neglecting other aspects of their lives.

She (12-04420) also ranked (s29) at +5 and had the following to say:

> I think teachers can be at their best when they have come to a balance in their life in terms of work and homelife. When a teacher feels they need to sacrifice time for their family and personal (mental) well-being in order to meet the perceived work expectations, they cannot be the best teacher they can be.

This work life balance and the need to support teachers through professional learning resonates with the teachers on this factor.

The statements that loaded with low scores on this factor included s42, s4, s34, s33, and s16. Of the three participants that loaded on this factor, two ranked (s6) at -5. This statement cites an explicit focus on content and subject matter as a characteristic of effective PD. Participant 12-01320 said, “Some of my best PD has been in sessions that were not specific to any subject or

any grade level." In that same context, participant 12-03520 said, "Most of my colleagues know their content/subject matter extremely well, so professional development is better served introducing new teaching strategies." Those new teaching strategies vary by teacher. Participant 12-04420 said about (s4), "I think teachers from a variety of starting points can benefit from professional development. I think teachers who are doing things well in a particular area can still benefit from further professional development in that area." It seems that 12-03520 feels pushing outside of one's comfort zone leads to growth. He said about (s26):

> I think an important part of developing is becoming uncomfortable psychologically and working outside your usual comfort zone. Physical comfort isn't critical. The psychological comfort aspect is what causes people to fall back into their own habits and not push their growing edge.

Statement (s33) was ranked at -4 on this factor. This statement says time for shared problem-solving should be provided in PD. Participant 12-04420 ranked this statement at -5. She shared, "I don't think shared problem-solving is necessary for professional development to be effective. While a think-tank can be productive in certain situations, I think PD can still be effective without group input."

In summary, teachers that loaded on this factor suggest teachers require support, sometimes from peers, to successfully implement change in their classrooms. Sometimes this support is with the new content or skills knowledge presented in PD, but often it is on a more personal needs level. Teachers are busy individuals and PD adds to their plate of responsibilities (work and personal life). This factor indicates that PD does not necessarily need to focus on content and subject matter to be effective. Sometimes teachers need to be stretched or pushed outside their comfort zone to learn.

4.4 Consensus Statements

Factors are derived from the ideas in which participants have shared views on a particular topic or subject. Yet, in some instances, participants will rank a particular topic statement very similarly. In these instances, these statements are referred to as consensus statements. For this analysis, a Distinguishing and Consensus Statement report was run in R for both the mathematics teachers and the science teachers that participated in this study. From this analysis run for the science teachers, no consensus statements were identified. For the analysis run for the mathematics teachers, eight consensus statements were identified (see Table 18). Ranking lower across the three factors (all at -3) was statement (s32). This statement suggested that effective PD includes an analysis of student work samples. Ranking more neutral were statements (s17) and (s27). The first discusses a focus on pedagogy while the later focuses on PD that is long-term/continuous. Generally scoring high was statement (s40), with factor scores of 2, 4, and 4. This statement suggests PD should link directly to the day-to-day work of teachers.

Table 18: Consensus Statements-Mathematics

Statement	Factor 1	2	3
(s9) Effective professional development includes follow-up and support for transfer of learning to the school or classroom.	3	2	1
(s13) Effective professional development includes teachers being treated as a colleague and professional by facilitators of professional development.	1	2	1
(s14) Effective professional development includes providing teachers opportunities to take on leadership roles.	-2	-1	0
(s17) Effective professional development focuses on pedagogy.	0	0	-1
(s20) Effective professional development that models instruction helps teachers to visualize how to implement their new learning in the classroom.	1	1	3
(s27) Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings.	1	0	0
(s32) Effective professional development includes an analysis of student work samples.	-3	-3	-3
(s40) Effective professional development links directly with day-to-day work in real schools and classrooms.	2	4	4

4.5 Teachers' Definitions of Effective Professional Development

In part B of the Q survey, teachers were provided an open-ended question regarding effective PD: *In thinking about the idea of "effective professional development," how would you define effective professional development?* The responses from the science teachers and the mathematics teachers were analyzed separately. For the responses to this question provided by the science teachers, eight codes were used to define the themes present: (i) *results in change in practice*, (ii) *engaging/active learning, (iii) relevant/applicable to current work, (iv) collaborative, (v) benefit student learning/outcome, (vi) long-term, (vii) immediate use,* and *(viii) personal growth*. Table 19 provides information on the # of teachers' definitions as well as the percentage of teachers' definitions (out of n=30) that were coded with a particular theme. Some definitions from the teachers were multi-faceted and therefore were coded with more than one theme.

The two themes that appeared the most were *Relevant/applicable to current work* (n=12, 40%) and *Benefit student learning/outcomes* (n=11, 36.7%). An example of a statement for *Relevant/applicable to current work* came from participant 12-31120 stated, "Effective professional development is repeated multiple times over a school year, includes collaboration of other teachers, and directly relates to the content and/or students I work with." Another example of a statement for this theme was provided by participant 12-06320. He said, "An experience that actively engages me in learning and that experience directly can be applied to improving instruction in my classroom. I enjoy PD that is focused on specific content related to my courses." An example for the theme *Benefit student learning/outcomes* comes from participant 12-29120 who said, "I believe that teachers also need to believe that by implementing the PD, students will benefit and learning will increase." Participant 12-40420 said, "Effective

professional development will result in an improvement in teaching a particular subject. Students will have better demonstrable understanding of a concept." One idea of interest that was not coded on a theme since it was a sole response in its intent, participant 12-31620 shared about effective PD:

> It is also not presented by people who went to a weekend training or tried a few lessons in a classroom. It is presented by those who either researched and developed the material/techniques or by those who implemented it successfully in the classroom over several years.

What he seems to indicate is that effective PD is presented by experienced facilitators.

For the responses to this question provided by the mathematics teachers, seven codes were used to define the themes present: (i) *results in change in practice*, (ii) *engaging/active learning, (iii) relevant/applicable to current work, (iv) collaborative, (v) benefit student learning/outcome, (vi) long-term, and (vii) immediate use (personal growth did not appear within the definitions for this set of teachers*. Table 20 provides information on the # of teachers' definitions as well as the percentage of teachers' definitions (out of n=13) that were coded with a particular theme. Again, some definitions from the teachers were multi-faceted and therefore were coded with more than one theme.

Three themes tied for highest prevalence in the definitions (n=5, 38.5%). These were Results in change in practice, Relevant/applicable to current work, and Benefit student learning/outcomes. For Results in change in practice and Benefit student learning/outcomes, participant 12-49220 stated:

> Effective professional development motivates a teacher to think differently about teaching and learning to the extent that the teacher then wants to and has the proper

supports to make changes in their practice to increase student achievement over an extended period of time.

Table 19: Codes for effective PD definition: Science

Theme	# of teachers	% of teachers
Relevant/applicable to current work	12	40.0%
Benefit student learning/outcomes	11	36.7%
Results in change in practice	8	26.7%
Collaborative	7	23.3%
Immediate use	5	16.7%
Long-term	5	16.7%
Engaging/active learning	4	13.3%
Personal growth	3	10.0%

Table 20: Codes for effective PD definition: Math

Theme	# of teachers	% of teachers
Relevant/applicable to current work	5	38.5%
Benefit student learning/outcomes	5	38.5%
Results in change in practice	5	38.5%
Collaborative	1	7.6%
Immediate use	3	23.1%
Long-term	1	7.6%
Engaging/active learning	1	7.6%

Similarly, participant 12-22420 said:

> That would be a PD where all participants learn something that they can (and will, because they feel compelled by the PD) directly apply to their practice, so that positive student outcomes (ex., greater conceptual understanding of a topic, more equitable classroom environment) is achieved.

An example of *Relevant/applicable to current work* would be from participant 12-39920 who said, “PD that I can use in my classroom that makes sense to me. I like to see it related to my content. Sometimes it's difficult to take some ideas and apply them to math.”

4.6 Teachers' Views on the Q Sample

In part B of the Q survey, teachers were provided an open-ended question regarding the Q sample: In considering the aspects of effective professional development that were included in this survey, do you feel there was anything missing that should be considered? For the science teachers, 16 out of 30 (53.3%) felt that the Q sample was not lacking anything. As examples, participant 12-01420 stated, "No, this survey was thorough!" Participant 12-04720 said, "I feel it was a pretty comprehensive list." And participant 12-20320 stated, "No. I think you did a nice job of selecting many varied characteristics of PD for your ranking priorities." Two teachers suggested there should have been a question about the quality of the PD facilitator(s). One teacher also suggested that perhaps statements for virtual PD should be included given that they are currently participating in PD opportunities during a global pandemic. Other comments left by teachers would likely not be considered characteristics of effective PD per se. For example, "Teachers should be assessed on misconceptions in their field of teaching" was a suggestion by 12-53220. Participant 12-30820 shared, "I guess I was surprised that there was no statement about effective PD being tied somehow with technology, but I'm also glad it wasn't there. Good teaching strategies don't always need the latest fanciest technology."

For the mathematics teachers, 10 out of 13 teachers (76.9%) expressed nothing was missing from the Q sample. Participant 12-31920 suggested, "To expand on the having an immediate impact on the classroom." This, arguably, was covered in (s25). One mathematics teacher (12-22420) mentioned, like two science teachers, that the quality of the presenter is important. Participant 12-15320 expressed, "I don't remember seeing anything about professional development being led by actual classroom teachers." The intent of (s14) was to think about the types of leadership roles teachers take in PD.

4.7 Summary

The purpose of this chapter was to provide the results obtained through the analysis of the data that was collected via the Q survey. In addition to this quantitative data, qualitative information collected through part B of the survey instrument allowed for the interpretation of the factors that were extracted. The final chapter will discuss the results as they relate to the research goals of this study.

Chapter 5: Discussion and Implications

5.1 Introduction

This Q methodological study focused attention on the characteristics of effective PD for teachers. Lacking from the literature is the voice of the teacher in evaluating the essential characteristics that have continually grown in number. The previous chapters of this thesis defined the need for the study, introduced the theoretical framework, and provided evidence of how the research questions for this investigation are situated in the body of PD literature. The methodology used was also described, and the resulting quantitative and qualitative data obtained through the administration of the Q survey were provided. This chapter will discuss the results of the Q study in relation to the research questions, examine implications of the findings, and address limitations of this study. Opportunities for further research will be addressed as well.

5.2 Discussion of Research Questions

For this study, three research questions were explored. Each will be examined in depth based on the results obtained from the administration of the Q survey.

5.2.1 Research Question 1

What do science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on characteristics of effective professional development?

As described in Chapter 2, there has been a growing list of characteristics of effective professional development in the research literature (Cornas & Barufaldi, 2011; Guskey, 2003; Merchie et al., 2018). In order to answer this first question, the preparation of the Q sample for this study was the most critical aspect of the project. The importance of the Q sample cannot be minimized as it must be composed of statements and ideas that are representative of all the views

on a particular topic (Brown, 1980). Additionally, if reviewers of a study do not fully appreciate the validity of a Q sample, this may be a source of concern when reviewing the results of a Q study (Watts & Stenner, 2012). The process in which the Q sample was created was described in the methodology section (Chapter 3), yet an analysis of the Q sample used for this study deserves some discussion as the intent is to continue to utilize this Q sample for future studies and to establish this list of statements for other researchers to consider for their future research on PD.

The creation of a new Q sample for this study was necessary to appropriately capture the views of the teachers concerning PD. In a search of the literature, the only Q study regarding the effective characteristics of PD previously completed was a study by Brown & Militello (2016). However, since the focus of their study was principals' views, many of the statements that were included in their Q sample were not necessarily appropriate for use with teachers as the *P set* (person sample in a Q study). After an extensive review of the literature and the development of the concourse, coding methods (as described in Chapter 3) were used to reduce the statements to create the final Q sample. The selected statements were then evaluated by several education professionals prior to the administration of the survey to ensure adequate representation of the population of statements and the research on PD had been achieved.

Another way of examining the validity of the Q sample was conducted through the Q survey itself. In part B, an open-ended question was given to the teachers regarding if they felt any statements were missing regarding the effective characteristics of PD. 53.3% of the science teachers and 76.9% of the mathematics teachers expressed nothing was missing from the survey. Of the comments from the remaining teachers, one comment that was made by two science teachers (12-21320 and 12-46920) and one mathematics teacher (12-24420) that could potentially be added to the Q sample dealt with the quality and experience of the PD facilitator.

Certainly, in the literature on effective PD, the experience and expertise of the facilitator is considered in discussions of effective PD (Darling-Hammond et al., 2017). For this Q sample, the role of the facilitator was considered in two statements (s13 and s18), but perhaps an additional question could be considered by researchers in future studies. Another comment that was made by one science teacher, participant (12-47920), was how questions regarding virtual PD should be included in the set of questions. This recommendation is likely related to the current experiences teachers are facing due to the COVID-19 pandemic. This may certainly be considered in future studies, but in the literature review for this study, remote/virtual PD was not encountered.

Due diligence was taken to ensure the Q sample encompassed the body of literature on the characteristics of effective PD. Based on the results of the review of the Q sample by experts in the field for teacher PD, and given the responses from the question to teachers posed in the Q survey, it appears the Q sample is comprehensive in its makeup.

Having established the validity of the Q sample to show the comprehensive nature of the Q study, it now makes more sense to discuss *Question 1*, namely what science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on characteristics of effective PD. To gauge which characteristics the teachers viewed as most important to their learning, a review of the teachers' sorts was done. Through this view, each individual statement was analyzed to determine how high (or low) teachers rank each particular characteristic with regards to their learning. Statements that had the greatest number of *+5* and *+4* ratings corresponded to those characteristics that the teachers most identified with as being important to their learning. When viewed in this manner, there were several shared characteristics of importance between the science and mathematics teachers.

The two statement that received the most +5 and +4 ratings for the science teachers were (s5) and (s12). Each of these statements were ranked the highest by 33.3% of the science teacher participants (10 out of 30). Statement (s5) was *A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.* Teachers often don't have time to dedicate to learning, so they often gravitate towards opportunities that will support what they already do in their classroom (Guskey, 2002; Vanassche & Kelchtermans, 2016). Statement (s12) stated *Effective professional development allows teachers to experience learning rather than being passive learners*. Teachers want to engage in the learning process, and this often models the type of instruction that is encouraged of them as they implement their new skills and knowledge (Desimone et al., 2002; Patton et al., 2015; Stolk et al., 2011).

The next highest ranked statements by the science participants after this statement were (s27) at 30.0% of the participants (9 out of 30) and statements (s7) and (s40) at 23.3% of the participants (7 out of 30). Statement (s27) was *Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings*. This seems to indicate that teachers prefer to have the ability to dive deeper in a topic. One-off workshops typically limit the ability to do this, and are better for sparking interest in topics. Statement (s7) stated *Effective professional development programs can help teachers deepen their knowledge and transform their teaching*. In some ways this statement is related to the last statement because it is through long-term and continuous PD that teachers are able to go deeper in their knowledge to transform their teaching (Desimone et al., 2006; Fetters, 2003; Gravani, 2003). Statement (s40) was *Effective professional development links directly with day-to-day work in real schools and classrooms*. The same argument for

statement (s5) can be used for this statement as well as teachers are looking for connections to what they are already doing in their classroom to strengthen their current practice (Borko, 2004).

The highest ranked statement for the mathematics teachers was statement (s40) at 53.8% of the mathematics teacher respondents (7 out of 13) ranking that statement at +5 or +4. Although this statement was ranked high by both the science and mathematics teachers, the percentage of mathematics teachers ranking it high was more than double than the science teachers. Close behind this, and the next two highest ranked statements for the mathematics teachers, were (s12) at 46.2% of the participants (6 out of 13) and (s5) at 38.5% of the participants (5 out of 13). These were ranked similarly high by the science teachers, as described above.

Interestingly, when comparing the statements ranked highly by science and mathematics teachers, there were two statements where similar high ranking was definitely lacking. In looking at the science teachers, statement (s7) was ranked as a top choice for 7 out of 30 teachers, or 23.3%. However, in looking at the mathematics teachers for this same statement, only 2 out of 13, or 15.4% of the teachers, ranked this as important to their learning. Of those two mathematics teachers, neither rated this statement at +5, compared with the science teachers where four of the teachers gave this the top ranking. Since this statement is about PD helping teachers to deepen their knowledge and transform their teaching, this indicates a difference in what science and mathematics teachers seek from professional learning opportunities. One may question if science teachers pursue more opportunities to deepen their content knowledge, yet this study does not have a way of answering this question with certainty. Confirmatory information through additional research would be necessary.

Another statement where similar high ranking was lacking was statement (s20). In looking at the mathematics teachers, this statement was ranked as a top choice for 4 out of 13 teachers, or

30.8%. Two teachers ranked this statement at +5 and two teachers ranked it at +4. However, in looking at the science teachers for this same statement, only 1 out of 30, or 3.3% of the teachers, ranked this as important to their learning (at a +4 rating). This statement calls on PD that models instruction to help teachers visualize how to implement their new learning in the classroom. It would appear from the science participants in this study that this modeling of instruction is not as important for the science teachers to successfully incorporate new knowledge and skills. Mathematical modeling is a problem-solving approach used in the practice of mathematics, and therefore could explain why it was valued more-highly by the mathematics teachers (Kula Unver et al., 2018; Wake, 2016).

In summary, several things were learned regarding Question 1 through this study. In considering what science and mathematics teachers in grades 7-12 view as important to their learning when reflecting on characteristics of effective PD, they (science and mathematics teachers in the study) actually similarly ranked of high importance many of the same characteristics. Both science and mathematics teachers seemed to look for relevant learning that is related to and strengthens the work that they already do in their classrooms currently. They also want to be engaged in the learning process and not just passive recipients of information.

They did differ in a few areas as well. Science teachers want to know that the change being made will be of value to them. Science teachers also seek PD that is more long-term and continuous in nature, and dives deeper into content knowledge. Mathematics teachers did not rate the deeper dive into content knowledge nearly as high as the science teachers did. However, the one area mathematics teachers did rank significantly higher as important to their learning is that the implementation of new knowledge and skills needs to be modeled during professional learning opportunities. Interestingly, as will be described for question 3, one of the factors that

was extracted did indicate the importance of the modeling of instruction as important to science teachers, though when viewed as a lone statement, did not hold as much value on its own.

5.2.2 Research Question 2

What connections exist between the characteristics of effective professional development teachers view as being important to their learning and the core adult learning principles?

The theoretical framework that was selected for this research study, as described in Chapter 1, was adult learning theory (also known as Andragogy). Through *Question 2*, the hope was to learn if a connection could be made between the characteristics of effective PD teachers view as being important to their learning and the core adult learning principles. Each of the core adult learning principles (Knowles et al., 2015) were analyzed in relation to what the teachers ranked as the characteristics they most identified with.

As described in the methodology section (Chapter 3), during the selection of the Q sample from the concourse, the first step was to take the entire population of statements and stratify them into six categories based on the six core adult learning principles. Seven to eight statements per core adult leaning principle were ultimately selected for the Q sample. As it happened, for each of the six principles, there were elements that emerged from the teachers' highest ranked characteristics corresponding to these principles.

1. Learner's Need to Know (why, what, how)

In thinking about a Learners Need to know, Knowles et al. (2015) described this as "adults need to know why they need to learn something before undertaking to learn it…the first task of a facilitator of learning is to help learners become aware of the need to know" (pp. 43-44). The first statement that emerged for this core principle, and was ranked highly by numerous science and mathematics teachers, was (s5) (33.3% and 38.5% respectively). This statement said *A*

prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work. This fits with the idea that teachers, as adult learners, need to know why they are going to dedicate time to learning something new. In relation to this statement, participant 12-06320 said, "Ownership of the learning experience is needed for the teacher to get the most out the experience. Teachers need to know how this will directly help them with their students." So, for this teacher, they wanted to know exactly how their new learning would benefit their students. Participant 12-22420, a mathematics teacher, said:

> One of the first steps to a successful PD is to help participants understand why this is important and how it will help them become a more effective teacher. Unless teachers are convinced of the value of the PD, they are likely just biding their time to get PD hours, and hence the PD is not truly effective.

What he shared is similar to participant 12-06320 in that both want to know how participating in a particular professional learning experience is going to help them in their practice.

A second statement that was ranked highly by several science teachers (23.3%) was (s7). This statement was *Effective professional development programs can help teachers deepen their knowledge and transform their teaching*. This statement seems to correspond with the part of the definition of this first core principle that indicates facilitators can help learners become aware of the need to know. Participant 12-29120 said, "True PD will enhance a teachers content knowledge and help them to broaden their instruction. Ultimately, this will lead to better student understanding in the long run." Enhancing content knowledge likely comes from a facilitator successfully providing new content knowledge that challenges the teacher, resulting in new learning. Similarly, participant 12-06320 said about (s7), "I think this is a very important aspect of a PD experience. Having a greater understanding of a concept allows you to develop more

precise and effective methods of teaching." A third teacher, participant 12-01420, spoke about how she has been able to continually deepen her content knowledge, ultimately leading her to become a more effective teacher.

2. Self-Concept of the Learner (autonomous, self-directing)

Core principle number two speaks about how adults are "responsible for their own decisions, for their own lives...need to be seen/treated by others as being capable of self-direction...adult educators...make efforts to create learning experiences in which adults are helped to make the transition from dependent to self-directing learners" (Knowles et al., 2015, p. 44). Teachers, as adult learners, typically require less guidance and direction than a student would (Loucks-Horsley& Matsumoto, 1999), and therefore instruction needs to be delivered in a way that is going to promote engagement and integration of their learning into their practice (Borko, 2004; Darling-Hammond et al., 2017). One statement, (s12), emerged as a highly ranked statement from the science and mathematics teachers (33.3% and 46.2%, respectively). This statement was *Effective professional development allows teachers to experience learning rather than being passive learners*. In a way, this helps teachers transition from being dependent to self-directing. For participant 12-02620, this meant doing something active during learning. He said, "I think for the most part teachers appreciate doing something active during professional development opportunities rather than just hearing about the theory behind it." This method of instruction helps teachers envision how to implement new learning in the classroom (Borko, 2004). Participant 12-02820 spoke about how experiencing learning in the way her students would helped her in the transition to new mathematics standards. She said, "Diving into curriculum and seeing how students would view content and practicing the presentation of material with peers."

One participant, teacher 12-31120, spoke about his experiences in light of the pandemic and related it to professional learning he has participated in previously. He said:

> This year of pandemic teaching has taught me a lot about engagement of learners. Students that are at home and Zooming or Googling into class and only 'watching' have very low levels of retention. Even teachers (like myself) have a hard time paying attention in meetings that involve us being passive, especially online. Checking email or grading papers has become common during PD, and even those that are not distracted to that level are daydreaming and thinking of other worries. Passive learning is not learning.

It is interesting to see how he connected the engagement of students to his own learning needs. It would seem this impacts how he approaches teaching in his own classroom.

3. Prior Experience of the Learner (resource, mental models)

Core adult learning principle three takes into account that adults have prior experiences that they bring to the table (Knowles et al., 2015). Teachers, as such, are going to have prior knowledge and experiences that will influence their learning that students would not have (Loucks-Horsley& Matsumoto, 1999). Knowles et al. (2015) suggest, “techniques that tap into the experiences of learners like group discussions, simulation exercises, problem-solving activities, case methods, and laboratory methods instead of transmittal” (p. 45) should be considered. Statement (s20) was ranked high by 30.7% of the mathematics teacher participants. This statement said *Effective professional development that models instruction helps teachers to visualize how to implement their new learning in the classroom.* One teacher, participant 12-05720 commented. She said:

> When I feel like I am participating in a learning strategy I am usually aware of how I can (or sometimes can't) implement it directly in the classroom. If I have to think about how

> to apply the concept or the strategy into my classroom, and especially if that time isn't provided during the session I probably won't use it at all. When I see it modeled then I am [*sic*] instantly start to think about how it would apply to my classroom. I think about particular content it might be most helpful to support, or students that might gain the most.

The modeling of instruction has been shown to assist teachers in implementing new methods of teaching in their classroom (Lakshmanan et al., 2011).

4. Readiness to Learn (Life related, developmental task)

The fourth core adult learning principle discusses how "adults become ready to learn those things they need to know and be able to do in order to cope effectively with their real-life situations" (Knowles et al., 2015, p. 45). Participant 12-15720 seemed to capture the essence of what this principle would describe when applied to teacher PD. She said, "If teachers are not willing to change, then what is the point of professional development. The word development means growth and if teachers are not ready for growth, then the professional development will be meaningless for them." This would seem to suggest that teachers need to position themselves mentally to embrace improvement and change.

Statement (s27), which was ranked highly by 30.0% of science teachers and 23.1% of mathematics teachers in this study, was stratified into this core principle category. This statement said *Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings.* The reason this statement was stratified under this category was because of the continuous nature of PD that is being suggested. Instead of subjecting teachers to one-off workshops, a culture of learning that becomes routine can be established (Avalos, 2011). Participant 12-31620 said about this

statement, “Studies have shown we learn over time. The one time profession [*sic*] development offering can and will spark interest and enthusiasm for a concept. This can quickly fade if not allowed [*sic*] to work on the PD or collaborate with others.” Similarly, participant 12-31120 said:

> I feel that a one time professional development opportunity does not produce a lasting positive effect on teaching. It is like starting a new resolution because of the new year, maybe you work at it for a few days or a month, but then it is forgotten. Repetition of a task or strategy is the only way for me to develop new habits. Even a one time event that is life changing only has an impact for a short period of time in most cases.

This idea of *one-time* PD as not being supportive to long-term change was repeated by participants 12-30820 and 12-03520 as well. Participant 12-30820 went on to say, “Most of the time I just think of PD as the flavor of the month. It was there, it seemed cool, I tried a taste of it...but that was it”, while participant 12-03520 said:

> One day workshops tend to sound good at the time and offer some new and interesting ideas, but generally tend to hold little long-term carryover for me since there is no time for follow-up and to ask more questions when issues arise in the classroom.

Ongoing professional learning allows teachers the time to explore deeper, experiment, and implement with support from colleagues and PD facilitators (Darling-Hammond et al., 2017; Lieberman, 1995; Loucks-Horsley et al., 1996). Participant 12-49220 suggested:

> 6 months to 2 years of follow up in the form of regularly scheduled meetings/workshops to allow for progression of development and practice, just in time support for classroom implementation, and an established community of other teacher learners for continuous exchange of ideas and resources

Interestingly, this was very much the model of PD that these teachers experienced through the NYSMTP. Being allowed to participate in structured PD opportunities for four years provided a unique experience for many of the teachers, and allowed them to collaborate with peers. It has been shared by teachers from the program previously that this ability to collaborate with other teachers was especially helpful for teachers from rural districts who often were the only teacher in their subject area. Participant 12-28420 related something similar saying:

> When teachers get to build a community and share ideas that they are trying it helps to develop their pedagogy. As time goes on people begin to see what others are doing and how they can implement ideas better in their own classroom.

The support from other teachers in an ongoing way seems to help teachers implement long-term change as they can share their experiences and successes and work through the challenges (Kennedy, 2005).

5. ***Orientation to Learning (problem centered, contextual)***

In examining learning principle number five, Knowles et al. (2015) said "adults are life-centered (or task-centered or problem-centered) in their orientation to learning" (pp. 46). Teachers are often seeking PD opportunities to address certain needs in their practice (Patton et al., 2015; Saka, 2013). With the limited time they have to dedicate to professional learning opportunities, they need it to be meaningful. Several statements that received high rankings from teachers in this study included s30, s35, s36, and s37. Participant 12-04220, in speaking about statement (s30), described how:

> Teachers will attend professional development that directly aligns with the standards they teach. I seek out workshops on topics that I am being asked to teach that I may not feel

> confident with because of a lack of knowledge. I am also more apt to implement the strategies shown during the workshop if they align with my curriculum.

In this example, she indicates that PD that addresses the standards is what teachers seek out. She personally seeks out PD that is related to topics she teaches. For participant 12-21320, in discussing statement (s36), shared that resources obtained from PD opportunities that can be implemented in the classroom soon after a session are valuable. She said:

> I feel the most impact from PD when I leave a session with materials that I can immediately implement. Although some PD sessions have strategies that sound good or are intriguing, oftentimes the strategies are forgotten or due to time commitments are not implemented soon after PD or at all.

In examining statement (s36) further, it stated *Effective professional development includes resources and creative sessions similar to what is required by teachers in a classroom, so they can experience first what they are asked to put into practice*. By situating learning in ways teachers can experience learning they are asked to put into practice, they are able to put themselves in the shoes of their students to better understand what is needed for their learning process (Wilson, 2013). Participant 12-39920 shared, “It's nice to model how the program works. As a teacher you have a better idea of how to implement it yourself.” For participant 12-05720, what was important to her regarding this statement was the importance of having the capability of implementing something immediately. She shared, “Time is limited. If I have to spend time thinking about how to apply it, then I am less likely to use it.”

Participant 12-48420, a science teacher, discussed statement (s35) and its focus on student thinking. This teacher said:

> Understanding how students think is critical to finding ways to teach them. Sharing ideas about student thinking makes it a topic that is not always brought up but is essential in learning Teachers need to find ways to challenge their students and by being challenged themselves they can remember the struggles of being the learner.

It would seem the need to understand student learning is the problem-centered orientation to PD for this teacher.

Finally, participant 12-08820, a science teacher, focused on engaging teachers in the modeling aspect of the activities outlined in statement (s37). She said, "As a presenter, indeed the participants need to be active, the presenter needs to MODEL those activities being reviewed to augment classroom processes." This is a prime example of teachers being oriented to the type of learning that is expected of them.

6. Motivation to Learn (intrinsic value, personal payoff)

The final principle to be discussed looks at, "how adults are responsive to external motivators (better jobs, promotions, higher salaries, and the like)"...and "internal pressures (the desire for increased job satisfaction, self-esteem, quality of life, and the like)" (Knowles et al., 2015, p. 47). Participant 12-01320 summarized perfectly how this applies to teachers and PD. He described how, "Motivation is a tremendous factor in learning. We are busy professionals. Everything we invest time in is at the expense of something else we are not doing."

For teachers, what often motivates them when it comes to PD, is to seek opportunities that will benefit their classroom practice. As such, statement (s40) was stratified into this principle. This statement said *Effective professional development links directly with day-to-day work in real schools and classrooms*. Participant 12-44720 stated, "When PD is focused on at hand issues, in my building, I am much more likely to care." In this instance, it seems this may be

addressing quality of life (at work at least) for this science teacher. For participant 12-30820, if personal gain is missing from PD, then it seems this is not beneficial. She shared, “But the whole day PD my school made me go to that was on technology I do not have access to and how other people use it in their classrooms but I'll never be able to, never had my interest.” She was forced to attend PD that ultimately will not benefit her work.

While PD likely doesn’t result in promotions or higher salaries for teachers, it can improve their job satisfaction as it can lead to greater feelings of effectiveness (Connolly & James, 2006; Loucks-Horsley & Matsumoto, 1999). Finding things that can be used can go a long way in satisfying teachers’ needs. Participant 12-15320 shared, “this goes along with teacher buy-in. If I see what is being presented as something I could use daily in my classroom (and would make what I currently do better), then I will use it.”

Similarly, participant 12-32920 (s40) said:

> I want professional development that I can use - some things we have learned in the past are neat and creative, but if I can't use it with day-to-day work in my school and in my classroom then it really is obsolete.

Participant 12-49220, a Math educator, shared, “when my own (or teachers') ideas about learning are challenged by professional development, the result is a motivation to change thinking and practice about teaching and learning.” This statement echoes one from above (participant 12-01320), and helps to frame the thinking behind what motivates many teachers to choose to participate in PD.

5.2.3 Research Question 3

To what extent can the continually growing list of characteristics of effective professional development be narrowed down to specific factors that can be considered when designing professional learning activities for science and mathematics teachers.

As was described in Chapter 1 and throughout this study, a growing list of characteristics of effective PD has been described in the research literature for teacher PD (Cornas & Barufaldi, 2011; Guskey, 2003; Merchie et al., 2018). For this study, 168 statements were considered for the concourse. Trying to incorporate 1/2 or even 1/3 of these characteristics could prove challenging for a facilitator of professional learning opportunities, especially if one is conducting a short-duration, one-time workshop. As such, a goal of this study was to try and narrow the population of characteristics of effective PD down to a smaller, much more manageable, number of factors that could be considered by PD facilitators each when designing experiences for teachers. Through the use of Q methodology, it was possible to gain subjective insight from the teachers to learn what characteristics the teachers found important to their learning during PD. Utilizing principal component analysis with a Spearman correlation and cluster rotation, it was possible to extract a set of factors that represented those ideas that teachers found important to their learning.

When analysis of the Q sorts began, intentions were to conduct the analysis on all 43 participant sorts (30 science teacher sorts and 13 mathematics teacher sorts). However, upon running the correlations and extraction of factors in R for all 43 sorts combined, the resulting output of information was not consistent in nature. Analyses were run to extract 4, 5, 6, and 7 factors. In examining the data output for the varying number of extracted factors and comparing the number of sorts that loaded on each factor, the Eigenvalues for each factor, and the amount of variance across the variables, there were no obvious patterns that were observable in the output. In discussing the output with the statistics advisor on my dissertation committee, we decided to try running the analyses of the sorts of the science teachers and mathematics teachers separately from one another. Immediately, the output of the data made much more sense. What

was discovered through that process was that perhaps science and mathematics teachers find different characteristics of effective PD valuable to their learning. Further, while integration of science and mathematics is an intended goal of science reform (Bybee, 2014), there are still differences in the way problem solving in science and mathematics are approached (Bossé et al., 2015).

As such, through this Q methodological study, eight factors were extracted (five factors for the science teachers and three factors for the mathematics teachers). One reason a smaller number of factors were extracted for the mathematics teachers was that there was a smaller number of mathematics participants in the study. Therefore, it was not possible to extract as many factors for these teachers. Interestingly, while there are some similarities in the factors that were extracted for the science and mathematics teachers, they are not exactly the same as different statement rankings played their role in defining the factors. Each of the eight factors were defined in detail in Chapter 4 through the factor interpretation. The interpretations for each will not be duplicated here, but a brief discussion regarding each is below.

4.2.1 Factor 1 (Science): A focus on activities that model actual practice

Science teachers are often engaged in hands-on lessons with students through demonstrations and laboratory inquiry exercises that promote the ideas of the *nature of science* (Barnes et al., 2015; Loucks-Horsley & Matsumoto, 1999). As such, learning new skills and knowledge could include opportunities for teachers to play the role of investigator and/or student so that they can implement these practices successfully in the classroom (Sample McMeeking et al., 2012). It was, therefore, not completely a surprise, that science teachers in this study would find important to their learning opportunities to participate in activities that model what is expected of them for teaching science. As participant 12-04220 shared, “I want to learn techniques and teaching

strategies that are proven to be effective...I rely on professional development to show me new 'best' practices." This would seem to indicate, at least for this participant, that these new teaching techniques and strategies should be modeled or *shown* to teachers. Participant 12-08220 shared similarly about PD, "indeed the participants need to be active, the presenter needs to MODEL those activities being reviewed to augment classroom processes." This teacher indicates the modeling of activities supports changes in practice.

4.2.2 Factor 2 (Science): Collaboration with peers

One of the important aspects of the NYSMTP that these teachers participated in is that it utilizes a cohort-based model of PD in which teachers interact and work with each other as they complete their programmatic obligations. Teachers work closely with and support one another's learning, often through professional learning teams. So, uncovering that teachers participating in this study would value collaboration with peers was affirming for the work the program undertakes with educators. Participant 12-50520 shared, "I learn the most when I have time to interact and collaborate with my peers." While PD is often experienced for a short duration, teachers may be able to rely on one another for guidance as they implement new skills and can get necessary feedback (Desimone, 2009; Livneh & Livneh, 1999). Participant 12-40420, a physics teacher, shared more specifically about her time in the program, "The most benefit that actually translated into improvement for me in the classroom was the physics professional learning team because we were collaborating together and sharing experiences." Teachers are able to learn from one another's experiences. They are able to share what benefits their work in the classroom as well as help others to avoid what didn't work for them.

4.2.3 Factor 3 (Science): Continuous/Long-term learning with follow-up support

Creating a culture where professional learning is ongoing and not just one-off occurrences without cohesiveness is supported by teachers. Science is certainly not a stagnant field and continues to evolve as more discoveries are made. As such, teacher learning should not be stagnant. Participant 12-43920 said, "We need to continuously update what and how we teach based on the latest research available. This is a critical part of reflective teaching." Keeping up on the latest research allows educators to provide a relevant and timely connection to engage students (Main et al., 2015). Participant 12-31620 shared, "Having professional development which is not continuous and lacks follow through does not allow for teachers to improve." This seems to suggest that follow-up support for teachers is critical for realizing improvement, which is supported by the research literature (Darling-Hammond & McLaughlin, 2011; Patton et al., 2015). Similarly, participant 12-31120 said, "I feel that a one time professional development opportunity [*sic*] does not produce a lasting positive effect on teaching." Evidence was provided by teachers in this study that ongoing learning is supported over more fragmented opportunities.

4.2.4 Factor 4 (Science): Immediate and useful connections to current classroom work

Teachers hope to leave PD opportunities with new knowledge, skills, and resources that they can implement readily upon return to their classroom (Loucks-Horsley & Matsumoto, 1999). Aligned with what the literature indicates, participant 12-21320 said, "I feel the most impact from PD when I leave a session with materials that I can immediately implement." Teachers are also seeking connections to the work that they currently do in their classroom (Vanassche & Kelchtermans, 2015). Participant 12-04720 said, "I think most teachers place great value on professional development that is practical and meets immediate needs." With this factor, there is

an indication that PD that is connected to what teachers are already doing in their classroom is preferred.

4.2.5 Factor 5 (Science): Teacher participation in creation and implementation

While only three participants loaded on this factor, the research literature does provide evidence that involving teachers in the creation of PD can be valuable. McDonald et al. (2003) said, "professional development activities for educators that are designed and conducted without benefit of inside perspectives are not worth the time and money they cost" (pp. 2). Involving the participants of PD in the design of PD can be beneficial to a facilitator as it allows the facilitator to learn about what the teachers need and desire for their individual growth (Avalos, 2011; Sample McMeeking et al., 2012). Facilitators can tailor the learning to a specific audience. Participant 12-53220 said, "When I have the say in planning the PD activity, it means more to me. I will then be actively engaged in activities that will support my PD." Teachers can also help to lead professional learning for one another, and often better learn the information in doing so (Poekert, 2012). As is identified in the PD research literature, participant 12-08820 shared, "In the classroom we strive to let our students be the 'teachers,' so too the most learning will occur when teachers can lead teachers." Through the *Master Teacher* program, several opportunities exist for teachers to co-create and co-lead professional learning for themselves and for other teachers as well. Being that teachers have experiences they bring to the table, it seems to be sensible to tap into that experience (Dadds, 2014).

4.3.1 Factor 1 (Mathematics): Engagement in active learning

The first factor to be extracted for the mathematics teachers defined the importance of teachers being engaged in active learning. Nearly half of the participant sorts (6 out of 13) loaded on this factor. Teachers do not want to be passive learners, but would rather be engaged in the

learning process (Darling-Hammond & McLaughlin, 2011; Vanassche & Kelchtermans, 2016). For example, participant 12-05720 shared, “When I feel like I am participating in a learning strategy I am usually aware of how I can (or sometimes can't) implement it directly in the classroom.” The engagement of teachers in activities applicable to their work aids them in transferring their new learning to their own classrooms (Vanassche & Kelchtermans, 2015). Teacher participant 12-39920 said, “It's nice to model how the program works. As a teacher you have a better idea of how to implement it yourself.”

4.3.2 Factor 2 (Mathematics): New learning is applicable to current practice

The PD literature suggests that learning that is applicable to teachers’ current practice is typically well-received (Guskey, 2009). Often this is due to the limited amount of time teachers have to dedicate to new learning (Buczynski & Hansen, 2010; Darling-Hammond et al., 2017). Certainly, this was a concern shared by participant 12-05720 as she shared, “Time is limited. If I have to spend time thinking about how to apply it, then I am less likely to use it.” Teachers are looking to apply new learning to what they are already doing to help improve their practice (Flory et al., 2013). Participant 12-15320 shared, “If I see what is being presented as something I could use daily in my classroom (and would make what I currently do better), then I will use it.” Taking this idea one step further, participant 12-32920 said, “If I can't use it with day-to-day work in my school and in my classroom then it really is obsolete.” It seems that from the literature, and from the participants in this study, that learning should, at least to an extent, be related to what teachers are currently responsible for in their classrooms.

4.3.3 Factor 3 (Mathematics): Support through change

While only three participants’ sorts loaded on Factor 3, this does not limit the importance of what teachers need to realize change in their practice. This factor indicates that teachers need

support as they proceed through the change process. Similarly related to this factor, arguably was Factor 3 from the analyses of science teacher information that suggested PD should be continuous and ongoing. Part of this ongoing nature of PD is aiding teachers through change (Avalos, 2011; Loucks-Horsley et al., 1996). This idea was certainly shared by participant 12-49220 who suggested teachers need:

> 6 months to 2 years of follow up in the form of regularly scheduled meetings/workshops to allow for progression of development and practice, just in time support for classroom implementation, and an established community of other teacher learners for continuous exchange of ideas and resources.

While the research literature does not necessarily suggest this time period (*6 months to 2 years*), there is a general understanding that change takes an extended amount of time (Buczynski & Hansen, 2010; Darling-Hammond et al., 2017). However, the idea that was echoed by another participant was the idea that other teachers can help provide the support needed to implement change. Participant 12-03520 said, "Having the support of colleagues who are trying to implement new strategies can serve as a sounding board, source of inspiration, and someone to push you forward if you hit a wall when trying to implement new strategies." Seeking ways to support teachers through the change process seems to be necessary to ensure successful change and improvement that teachers seek.

5.3 Implications of the Findings

This section explores implications of the findings from this study. To be discussed will be implications for in-service science and mathematics teachers based on what they identified as important to their learning. This may have implications for work with preservice teachers as well. Next, implications for facilitators who are designing PD learning opportunities for teachers

will be discussed. Finally, implications for PD researchers interceded in the characteristics of effect PD will be explored.

5.3.1 Implications for In-service Science and Mathematics Teachers

This study helps to give voice to science and mathematics educators and what they feel is important to their learning in considering the characteristics of effective PD. This was considered through two different research questions (Question 1 and Question 3). Question 1 looked at which characteristics teachers ranked the highest in a Q sort that ranged from -5 to +5. All statements from the Q sample that were considered for this analysis were ranked at +5 and +4 by the teacher participants. Certainly, of great importance to these teachers was that they want to experience and be engaged in active learning rather than being passive learners. Teachers also want to know that change they are implementing is relevant to their current work, and can be implemented immediately as their time is limited. Further, they are seeking ongoing learning and support through the change process and find one-time PD opportunities to be less impactful for their learning. Finally, teachers are looking for professional learning opportunities that model the type of teaching that is expected for teachers to integrate in their classrooms based on the their newly learned skills and knowledge.

Question 3 explored whether it is possible to narrow down the list of characteristics of effective PD. Through this process, eight factors were extracted through this Q methodological study. These factors were explained in detail in Chapter 4 and discussed in the previous section (5.2). What should be noted is that there are obvious similarities between the extracted factors and some of the high-ranking statements of participants. This would be expected as the correlation of the sorts is based on the rankings the teachers place on the statements. However, instead of individual statements (or characteristics) what is being considered is a combination of

characteristics that are included within a factor. These factors articulate what teachers find as beneficial and supportive to their learning.

The results of this study could have implications for work with pre-service teachers as well. Certainly, some of the core adult learning principles from Knowles' adult learning theory should be incorporated in the way pre-service teacher learning is viewed. Specifically, in considering core principle two and the ideas of self-concept, I believe my role as a science methods instructor is to help students transition to being a self-directed learner. They need to become self-reliant if they are going to soon have a classroom of their own. Therefore, I scaffold learning such that the students are responsible for seeking out information they need to succeed on assignments that mirror what they would need to do as teachers. I also engage pre-service students in active learning opportunities that are meant to better prepare them to integrate active learning strategies in their future classrooms. Since active learning is favored by in-service teachers, as demonstrated by this study, it makes sense to prepare pre-service teachers in this same manner.

Peer-to-peer collaboration was shown to be of value to teachers in this study. Designing experiences where pre-service students are asked to collaborate with their peers to develop lesson and activities could help prepare them to work in supportive ways with their future colleagues. One complaint I often hear from in-service teachers I work with is that they feel isolated in their work, especially if they are the lone teacher of their subject. Therefore, preparing these students to find ways to communicate and collaborate with fellow educators in the future may prove to be a valuable and beneficial skill.

5.3.2 Implications for Facilitators of PD

Facilitators of PD can benefit greatly from the results of this study, First and foremost, it is impossible to fathom needing to consider well over 100 different characteristics of effective PD

when designing professional learning opportunities for educators. As someone that coordinates PD for teachers, this is not really possible, especially when needing to design short-duration activities. For longer-duration activities, it is certainly possible to include more of the characteristics, but certainly not all. This study provides a roadmap that was used to narrow a large population of characteristics to 44 statements that were then considered by a group of *master* teachers. By quantitatively analyzing the subjective thoughts of teachers through Q methodology, and combining that with qualitative information, it was possible to extract just eight factors (Five for science and three for mathematics). By narrowing the list of even 44 characteristics to eight could ease the burden on PD facilitators. Ensuring their professional learning activities are found to be effective by teachers for their learning needs is of importance to PD facilitators.

It is suggested that PD facilitators consider what teachers believe is important to their learning. They have lived experiences and often recognize what they need to support their teaching practice. This is different than working with students who typically require much more guidance to succeed. By taking the time to work with teachers, and even to include them in the design and facilitation of PD, may lead to greater learning gains from the teachers as well as buy-in to participate in change efforts.

Time needs to be built into PD opportunities for self-reflection and reflection with peers. As teachers are allowed the opportunity to evaluate their learning, as a facilitator, it makes it possible to determine what additional supports teachers may need. Additionally, implementation and integration of new knowledge and skills may take time and may require multiple sessions with time in-between sessions for teachers to try things out in their own classrooms. Again, facilitators should consider ways to support this level of learning with teachers. Moving away

from one-time offerings can lead to more success, and is supported by teachers, at least in this study.

5.3.3 Implications for PD Researchers

This study provides implications for PD researchers who seek further understanding regarding the characteristics of effective PD. The teacher's voice has been taken into consideration for the analysis of these characteristics. While this study looks at a subset of teachers and fails to include educators from all grade levels and disciplines, a majority of the characteristics that were included in the Q sample could be used with other groups of teachers as they are not specific to science or mathematics educators. By conducting further Q methodological studies, it will be possible to increase the validity of the Q sample. Certainly, if one would like to tailor the Q sample to better assess the views of other groups of educators, this is possible.

The theoretical framework that was used for this study, andragogy or adult learning theory, also helped in observing the characteristics of effective PD through another lens. By stratifying the characteristics into the six core adult learning principles, it was possible to begin narrowing down the concourse of statements until the Q sample was finally selected (through a series of steps outlined in Chapter 3). By overlaying those items that teachers identified with being important to teachers' learning with the adult learning principles, it is possible to appreciate the value in using this framework. This framework aids in understanding how adults learn so as to better meet their needs.

One surprising thing that was learned through this study was that teachers may question the importance of research-based PD that is built upon theory. This statement (s3) ranked low for many teachers, especially the mathematics teachers. This result should be evaluated more closely

as those of us who focus on PD research may need to improve the communication of the importance of our work with teachers. Including teachers in the research process, as was done in this study, may prove beneficial to doing just this. I was pleased that several of the teachers that participated in this study emailed that they are interested in the results of the study and would like to read the results when they have been finalized.

The representation from teachers of color in this study was lacking. All but one participant identified as White/Caucasian. Within the NYSMTP, the population of teachers of color is approximately 2%. Nationally, when considering educators of color that teach adolescence STEM courses, just 6% identify as Black (National Science and Math Initiative, 2020). In my examination of the research literature, I did not see information regarding how the characteristics of effective PD that are valued by teachers may differ for teachers of color versus White/Caucasian teachers. Unfortunately, this study does not help the literature in this matter. However, this study could easily be replicated with teachers of color to compare the results from the two studies. Much more work needs to be done to establish an understanding of how views of the characteristics of effective PD may differ amongst different groups of teachers.

5.4 Limitations of this Study

As can be expected, there are several limitations to discuss for this study. Probably of greatest influence on the study was the P set (in the case of this study, the teacher participants) that was used in this study. In looking at the teacher participants, these were all seasoned educators ranging from 6-10 years of experience up through 26+ years of experience. Of the 43 teachers that participated, only one teacher had less than 11 years of experience. Eleven teachers had 26+ years of experience. The rest fell in the middle of these two bookends. So, one glaring miss in the P set, and therefore in the results presented, is the lack of racial diversity in the

participants. Only one teacher out of the 43 (2.32%) did not identify as White/Caucasian. Therefore, it is difficult to know how the results may have differed for this study if the sample was more-representative of the teachers in our schools. Within adolescence STEM education, 6% of teachers identify as Black (National Science and Math Initiative, 2020).

Also lacking from the dataset is what more novice teachers find important to their learning when seeking out professional learning opportunities. Teachers may require different supports at different stages of their careers (Drago-Severson, 2000; Jeanpierre et al., 2005). Also, of note, participation in PD for teachers is compulsory if they do not hold permanent licensure, a designation that was discontinued for teachers in NYS in 2004 (NYSUT, 2017). Therefore, a majority of the teachers in this study with 16+ years of experience hold permanent licensure (30 out of 43 or 69.8%) are not required to complete PD to maintain their state licensure (though they may have individual district requirements). Given that these teachers largely are not subjected to mandatory PD, veteran teachers may have more flexibility and say in the PD they participate in if it isn't required to maintain their certification. They also have a choice in whether or not they want to participate in PD.

Another consideration for the teachers that were included in the P set, as mentioned previously, is that they were all designated *Master Teachers*. They have previously been identified through a rigorous selection process to be some of the top science and mathematics teachers in NYS based on their content skills and pedagogical knowledge. Their viewpoint on and goals for PD may not be equivalent to other teachers that have not been selected to participate in the NYSMTP. Further, teachers in this program participate in an extensive amount of PD (a minimum of 50 hours) each year for four consecutive years. This has allowed the teachers in the program to be exposed to a number of types of PD focused both on content and

pedagogy. Of concern with this population of teachers is that they are getting more PD than probably their colleagues who truly need the additional support (Desimone et al., 2006).

They were also compensated for meeting their programmatic obligations, which would be a motivating factor for completing PD. Questions may also exist if the results of this study could be generalized to teachers outside of this state as PD requirements will vary from state to state. Motivating factors (internal or external) to participate may be different for teachers in other states.

Another limitation was the smaller sample size of mathematics teachers. However, in comparing the P set with all teachers in the person population, it was revealed that the science to mathematics teacher ratio was actually very similar between the population and the sample. Stephenson (1980) would certainly argue the validity and value of even a small P set for a Q methodological study.

One consideration for the response rate being smaller than hoped could be the timing that this survey was administered. Teachers were approximately ten months into the COVID-19 pandemic. During this time, teachers have been subjected to a very stressful instructional pattern that has found them largely teaching in fully-remote or hybrid models of teaching. As such, they have had to reimagine their teaching, leading to several tensions (Radloff et al., 2021). Teachers had little time for extras, such as a survey like this that required 30-45 minutes of their time. However, some consideration was taken as to when a good time would be to launch the survey in light of a pandemic. Early January was selected as this was immediately following the holiday break when teachers may have been reenergized from their school vacation. This is also a time when teachers are generally not pressured by grading or the administration of examinations.

Finally, when considering the P set, this study was limited to science and mathematics teachers in grades 6-12 (middle school and high school teachers). Therefore, the generalization of the results of this study to teachers across all grade levels and disciplines seems unlikely. Slight difference could already be seen between science and mathematics teachers in this study. Therefore, the characteristics of effective PD that one demographic of teacher may find important to their learning may differ from another demographic of teacher (e.g., an elementary level ELA teacher versus a high school technology teacher).

Outside of the P set, another potential limitation to this study is that it was conducted solely via a computerized instrument. There was no actual connection made with the participants beyond the email invitation to participate and any reminder emails. This lack of connection between the researchers and the potential participants may have resulted in a lower response rate (Pedersen & Nielsen, 2016). Individuals may be more inclined to participate in a study like this if approached personally in a face-to-face interview (Pedersen & Nielsen, 2016). Another consideration around the computerized nature of the exam is the idea that many individuals are fatigued by the increased amount of screen time that has been inherent with the COVID-19 pandemic (Wiederhold, 2020). Perhaps teachers would have been more interested in participating if they weren't already spending so much time at a computer daily.

A limitation that was faced during the analysis of the Q sorts was the fact that, by using *R* to run the analysis, I was restricted to utilizing principal component analysis although centroid factor analysis tends to be favored by Q methodologists (McKeown & Thomas, 2013). This is because "PCA is not factor analysis and components are not factors" (Watts & Stenner, 2012, p. 99). The results obtained when using the two methods have been found to be very similar

though. An opportunity does exist for the future to see if the results are similar if the analysis is completed using both methods.

Specific to Part B of the study (open-ended and demographic questions), an additional limitation was because this study was conducted solely via a computerized instrument, it was not possible to follow-up on teachers' responses with follow-up probing and/or clarifying questions. The data collected was limited to what teachers provided in their written responses. While this may have resulted in more composed responses due to the lack of pressure to answer something immediately, richer information may have resulted from an in-person interview. Yet, the method of data collection used was actually beneficial as well when considering the social distancing requirements that were in place at the time of survey administration.

5.5 Opportunities for Further Research

This research study has helped to chart a path for future research to consider what is important for teacher learning when thinking about designing PD around characteristics that ensure an effective learning experience. This study, with its focus on adolescence education science and mathematics *Master Teachers* solely, leaves the opportunity for multiple lines of study in the future. Certainly, repeating this study with a similar population of teachers would be in order to affirm the results of this study. Increasing the sample size in a Q methodological study will not necessarily lead to improved results (Brown, 1980; Watts and Stenner, 2012), yet repeating the study with a similar P set could be in order to see if the results of this study hold true for similar teachers. Thinking about other frameworks beyond adult learning theory may result in thinking about the analysis differently as well.

Since this study focused on adolescence education science and mathematics teachers solely, additional studies using the same Q sample could be conducted with other populations of

teachers (e.g., elementary mathematics teachers, high school foreign language teachers,). The statements that are part of the P set in this study are broad enough in nature. An important comparison that needs to be made is whether there would be a difference in the results if the P set was more racially diverse.

Another potential opportunity would be to execute studies that are more comparative in nature. For example, a study could be designed to compare *Master Teachers* with teachers that have not necessarily had the same structured access to PD opportunities to determine if there is a difference in which characteristics are considered important to teacher learning. This may result in the extraction of different factors from the two comparative groups (teachers designated as *Master Teachers* versus those that do not hold this designation. Another comparison that could be examined is novice teachers versus more veteran teachers (as the teachers in this study were fairly experienced (42 out of 43 participants, or 97.7% of the teachers, had eleven or more years of teaching experience).

A longitudinal study of if/how teachers' perceptions change regarding the characteristics of effective PD over an extended period of time would be a valuable line of study as well. This could be one way to assess how the professional support teachers require differs at various stages of their career (Drago-Severson, 2000; Jeanpierre et al., 2005). As an example, less-experienced teachers may seek out more content-focused PD while teachers with greater experience may be seeking additional pedagogical tools (Cochran-Smith & Lytle, 1999). More specific to teachers associated with the NYSMTP program, it would be interesting to conduct this study with teachers prior to them entering the program and to conduct the study again with the same group of teachers at the completion of their 4-year fellowship to determine if a structured program of

PD influences which characteristics of effective PD this group finds more important to their learning prior to and after such a program.

Another line of study for the future would involve examining the methods facilitators utilize to implement PD. It would be interesting to measure teachers' satisfaction with PD that a facilitator typically does, and then looking at teacher satisfaction if facilitators redesign PD opportunities to include the factors that emerged in this study (if these factors are not already in use by a facilitator). In doing so, this could provide a measure of reliability for these extracted factors. If teacher satisfaction improves with PD facilitators' use of these factors, this would be confirmatory information that these factors support improved teacher learning.

Finally, applying at least some of the factors from this study to the design of pre-service science and mathematics methods courses could be explored in future research. Recognizing that the factors in this study represent the aspects teachers feel are important to their personal professional growth, introducing pre-service students to these ideas and practices may result in better preparation for these future teachers. A longitudinal study could be used to see if differences exist in the confidence of these novice teachers as they proceed through their first few years of teaching. Additionally, their views on professional learning may vary from other novice teachers who do not receive similar experiences as students.

5.6 Concluding Thoughts

In summary, this Q methodological study provided an opportunity to examine the characteristics of effective PD through the subjective lens of teachers that participate in professional learning opportunities. By more closely examining the characteristics of effective PD and understanding teachers' perceptions regarding these characteristics, facilitators of PD can better align PD activities to the needs of the teachers being supported. Teachers' views should,

and can, be more fully included in evaluations of effective PD. Beyond that, researchers can only conjecture as to what teachers value as important to their learning. The hope is to provide meaningful experiences for teachers that provides them with the knowledge and skills necessary to excel in their professional lives. A personal goal, based on the results of this study, is to include the factors that the teachers in this study indicated supports their learning in the design of future professional learning opportunities for teachers.

Appendix A—Dissertation Concourse

1. Working with teachers from **different** disciplines helped to strengthen my learning in my individual discipline.
2. Traditional models of PD take the form of expert-driven one-shot workshops.
3. Schools as learning organizations need to provide teachers with time and facilitation to jump-start new ideas and fine-tune promising teaching strategies given students' reaction.

(Mak & Pun, 2015)

4. Most of the in-service training or staff development that teachers are now exposed to is of a formal nature. Unconnected to classroom life, it is often a mélange of abstract ideas that pays little attention to the ongoing support of continuous learning and changed practices.
5. Working with teachers from my same discipline helped to strengthen my learning in my individual discipline.

(Lieberman 1995)

6. My school administrators promote models of professional development that consider the organizational context, culture, and climate in which I work.

(Drago-Severson, 2000)

7. Adults feel the need to learn and have input into what, why, and how they will learn.
8. Having choice in the professional development that I participate in is beneficial to my practice.
9. Choosing problem areas that have been identified by the learners through self-diagnostic procedures.
10. Teachers, as adults, are committed to learning when the programme's goals and objectives are job related and perceived as being immediately useful.

(Gravani, 2012)

11. They asked for 'more resources' to have been used and 'more creative' sessions to have been delivered by academics. They certified this position by explaining that this is what 'is required by teachers in a classroom', therefore in order for them to put it into practice they should have experienced it first.
12. Learners' previous experiences need to be taken into account in selecting methods and materials, in making presentations, and in helping learners to modify and transform the meanings and skills derived from their previous experiences.

(Gravani, 2007)

13. I am more committed to the professional development offerings where I am actively involved in the development by sharing my needs and problems.

(Gravani, 2012)

14. Opportunities for follow-up on what I have learned through professional development is an important aspect that aids me in adopting and implementing new content and pedagogy initiatives.

(Flory et al., 2014)

15. Having time to process and reflect on the professional development I partake in is important helps to internalize what I am learning.
16. That professional development not only involves changes in professional practice (actions), but also in practitioners' thinking about the how and why of that practice.
17. All teacher educators underscored the importance of data from their actual practices as the starting point for their critical and systematic reflection.

(Vanassche & Kelchtermans, 2016)

18. Being part of a network of other like-minded professionals that are interested in learning leads to changes in my teaching practices.

(Lieberman, 1995)

19. Having open dialogue with other teachers can have educational implications and purpose.
20. Combinations of tools for learning and reflective experiences serve the purpose in a better way.

(Avalos, 2011)

21. Experiencing learning is favored over being taught at.
22. Motivated to learn as they experience needs and interests that learning will satisfy.
23. The appropriate units for organizing adult learning are life situations, not subjects.
24. The role of the teacher (of Adults) is to engage in a process of mutual inquiry with them rather than to transmit his or her knowledge to them and then evaluate their conformity to it.

(Knowles, 1978)

25. Professional development that allows me to balance personal life situations (child care, possible financial and family issues, other teaching responsibilities, etc.) is important to me.
26. Moreover, it is required to connect the lesson's subject with the trainees' needs and experiences.
27. To make their needs and expectations of the program known so they themselves can feel that they are participating in its formation.
28. The educator is obliged to know that the adults want to learn so they can use the knowledge in their every-day life and not to develop general academic skills.

(Giannoukos et al., 2015)

29. I learn more from professional development that is long-term/continuous when compared to one-time professional development offerings.

(Lieberman, 1995).

30. Creating and leading professional development helps to strengthen my understanding of a particular topic.
31. All teachers from school involved in professional development activities.
32. Leads session during professional development.
33. Practices learning or receive feedback.
34. Develops assessments.
35. Receives coaching or mentoring.
36. In-depth study of specific content concepts.
37. Alignment of curriculum to standards.
38. Study how children learn concepts.
39. Specific instructional approaches to content

(Blank, 2010).

40. High stakes accountability, like APPR, is something I consider when deciding on the professional development I participate in.
41. It is important that teachers experience activities that permit them to study scientific problems which are current, relevant, and can be processed in a way that enables them to use collected data to make scientific meaning of the questions.

(Ebert & Crippen, 2010)

42. Professional development is an important way for me to make changes to my teaching practice.

(Avalos, 2011)

43. I am motivated by my own goals and beliefs, and look for value-added opportunities for my personal working conditions.

(Vanassche & Kelchtermans, 2016)

44. Phase 1 research provides evidence that high-quality professional development programs can help teachers deepen their knowledge and transform their teaching.
45. Professional development programs that include an explicit focus on subject matter can help teachers develop these powerful understandings.
46. Teachers generally welcome the opportunity to discuss ideas and materials related to their work, and conversations in professional development settings are easily fostered.
47. A good facilitator that can establish a community around the work that is being done is crucial to the success of teacher learning in professional development.

(Borko, 2004)

48. Change takes time and persistence.
49. Individuals go through stages in the change process and have different needs at different stages.
50. Change strategies are most effective when they are selected to meet people's needs.
51. Administrative support and approval is needed for change to take place.

(Fetters, 2002)

52. I look for professional development that has activities and materials for teachers to take with them.

(Borko, 2004)

53. Professional development that models instruction helps me to visualize how to implement my new learning in the classroom.

(Brown et al., 2014)

54. Professional development would be more-effective if there was participation of teachers from my same school, department, and/or grade.
55. We found that professional development focused on specific instructional practices increases teachers' use of those practices in the classroom.
56. Furthermore, we found that specific features, such as active learning opportunities, increase the effect of the professional development on teacher's instruction.
57. High-quality professional development includes providing teachers opportunities to take on leadership roles.
58. Promotes coherence in teachers' professional development, by incorporating experiences that are consistent with teachers' goals, aligned with state standards and assessments, and encourage continuing professional communication among teachers.
59. First, we asked each teacher to report the extent to which the activity the teacher attended was consistent with the teacher's goals for professional development.
60. Coherence: whether they had discussed what they learned with other teachers in their school or department who did not attend the activity.
61. Teacher participation in professional development that focuses on a particular teaching practice predicts increased teachers' use of that practice in their classrooms.
62. Our findings are also consistent with the idea that professional development characterized by "active learning," where teachers are not passive "recipients" of information, also boosts the impact of professional development activities.

(Desimone et al., 2002)

63. While professional development programs are needed to provide an initial vision for change, networks of colleagues can be the motivating factor that sustains the work for change over time.
64. Teachers need to know both the subject matter and how students can best learn the subject. Science teachers rarely receive training in both science and process.
65. Collegiality is a desired outcome of professional development that must be fostered.
66. Being treated as a colleague and professional by facilitators of professional is important to me.

(Dresner & Worley, 2006)

67. I felt supported in my learning when I am able to network/collaborate with other teachers.
68. Collaborative reflection with other teachers is an important part of my growth.

(Fazio, 2009)

69. During professional development, opportunities to demonstrate learning should be made.
70. Successfully translate inquiry to their classrooms were: deep science content and process knowledge with numerous opportunities for practice.

(Jeanpierre et al., 2005)

71. Student performance in my classes improves when I feel more effective in my teaching abilities.

(Lakshmanan, et al., 2011)

72. PD that involves teachers' contending with student thinking and considering the implications for instruction is important to my learning.
73. Effective PD ensures teachers are immersed in inquiry experiences and witness models of inquiry teaching.
74. Effective PD considers that my physical and psychological comfort is taken into account.
75. Effective PD provides curriculum materials are educative for teachers and students.

(Wilson, 2013)

76. Professional Development feels like an obligation.
77. Professional Development is an opportunity.

(Patton et al., 2015)

78. Having the ability to decide what I will learn based on my needs makes me more committed to professional development.
79. Professional Development must be collaborative, involving the sharing of knowledge among educators

(Darling-Hammond & McLaughlin, 2011).

80. Engagement in a professional community that extends beyond classrooms and school buildings has been identified as a powerful form of teacher learning
81. Using my classroom as a a site for intentional investigation leads to improvement in my practice.
82. I feel that the more I know (e.g., more subject matter, more educational theory, more pedagogy, more instructional strategies) the more effective I am as a teacher.
83. To improve, teachers need to implement, translate, or otherwise put into practice the knowledge they acquire from experts outside the classroom.
84. Teacher learning is no longer seen as a process of periodic "staff development".
85. Teacher learning is now more constructive and less "transmission oriented".

(Cochran-Smith & Lytle, 1999)

86. I value opportunities to engage with other teachers.

(Deglau & O'Sullivan, 2006)

87. Administrative support of reform is important for the success of Professional Development.
88. Stable, consistent leadership increases the chance of success in building and maintaining an environment for change.

(Kilbane, 2009)

89. Generic staff development programs (required in-service education activities) often fail to meet my needs a professional.
90. Having varied activities to choose from approach to professional development gives participating teachers an important measure of flexibility and self-determination.
91. I seek out Professional Development facilitated by outside "experts" that offers a set of workshops on topics selected to appeal to the broadest possible audience.
92. I am more capable of serving in a leadership role for other teachers because of the networking opportunities I have had (teaching other teachers; willingness to experiment).
93. Teachers are willing and eager to be involved in activities that challenge them and that promote their professional growth.

(Lieberman & McLaughlin, 1992)

94. Opportunities for teachers to engage in active learning are also related to the effectiveness of professional development.
95. Having time to try out new practices in-between Professional Development sessions helps contribute to my success in incorporating change.

(Garet et al., 2001)

96. Suggests that impactful and sustained professional learning for teachers is related to student-achievement gains.
97. Professional development that focuses on specific content and how students learn that content has larger positive effects on student achievement outcomes, especially achievement in conceptual understanding.

(Darling-Hammond et al., 2009)

98. It must be connected to and derived from teachers' work with their students.

(Darling-Hammond & McLaughlin, 2011)

99. Professional development that has a focus on the content I teach.
100. Professional development that focuses on classroom management.
101. Professional development that focuses on teaching students with special needs.
102. Professional development that focuses on using technology in the classroom.
103. I prefer Professional Development that is part of the scheduled work day.

(Darling-Hammond et al., 2009)

104. Research suggests that professional development is most effective when it addresses the concrete, everyday challenges involved in teaching and learning specific academic subject matter, rather than focusing on abstract educational principles or teaching methods taken out of context
105. It is often useful for teachers to be put in the position of studying the very material that they intend to teach to their own students.
106. Increasing the number of hours of PD I do in a year has had a larger impact on my classroom practice.

107. The PD I decide on participating in is often based on whether or not there is a cost I am responsible for paying.
(Darling-Hammond et al., 2009)

108. Professional development should engage and empower teachers to have a stronger voice in directing their own learning

109. Professional development should establish environments conducive for nurturing collegial relationships.
110. Professional development should shift away from solely providing content for improved teaching
(Still & Gordon, 2009)

111. Effective professional learning is one of the most potent strategies for improving student outcomes through the mechanism of increasing teacher effectiveness and, thereby, enabling improvements to pedagogical practice.

112. CPD is essential for practitioners to enhance their pedagogical content knowledge and skills and, in turn, to enhance student outcomes.
(Main et al., 2015)

113. The content focus of teacher learning may be the most influential feature.
114. The third core feature emphasized in the literature is coherence, the extent to which teacher learning is consistent with teachers' knowledge and beliefs.
115. Support for activities that are spread over a semester (or intense summer institutes with follow-up during the semester) and include 20 hours or more of contact time.
116. Professional development increases teachers' knowledge and skills
117. Professional development changes teachers' attitudes and beliefs.
118. Teachers use their new knowledge and skills, attitudes, and beliefs to improve the content of their instruction or their approach to pedagogy, or both
119. The instructional changes foster increased student learning.
(Desimone, 2009)

120. There needs to be a direct link between PD and my day-to-day practice.
121. There is benefit if several members of a school attend PD together.
122. There is benefit to spreading out PD over a number of days/sessions.
123. It is helpful when PD includes follow-up sessions or refreshers.
(Main et al., 2015)

124. PD designed to reform science instruction should build into its model continual opportunities for teachers to reflect and collaborate.
(Herrington et al., 2016)

125. In-service PD to advance teaching is important.
126. Principals have knowledge of their teachers' pedagogical and subject matter.
127. High-quality PD includes collaboration with experts.

(Brown & Militello, 2016).

128. High quality PD requires participation by teachers from the same grade or subject.
129. In particular, sustained, content-focus professional development has emerged as perhaps the most important type of in-service teacher education.
(Desimone et al., 2006).

130. Collaborations with other teachers inhibits my ability to progress in my learning in PD.
131. Professional Development needs to be aligned to other reform initiatives.
132. PD should include the analyses of student learning data to guide learning activities.
(Guskey, 2003)

133. The activities were designed to help teachers better understand both what they teach and how students acquire specific content knowledge and skill.
(Guskey & Yoon, 2009)

134. In order for teachers to transform their practice given their learning from the teacher community, supports from colleagues, school administration, and parents are vital.
(Barley & Pun, 2015)

135. What characterizes profession learning opportunities is that their lifespan is not one or two days. Instead, they become part of the expectations for teachers' roles and form an integral part of the culture of a school
(Lieberman, 1995)

136. The need for diverse and credible PD trainers emerged as an essential component of culturally competent PD.
137. It must engage teachers in concrete tasks of teaching, assessment, observation, and reflection that illuminate the processes of learning and development.
138. It must be grounded in inquiry, reflection, and experimentation that are participant-driven.
139. It must be collaborative, involving a sharing of knowledge among educators and a focus on teachers' communities of practice rather than on individual teachers.
(Darling-Hammond & McLaughlin, 2011)

(1) Effective professional development includes an analysis of student work samples.
(2) Effective professional development includes time to collaborate with peers.
(3) Establishing a collaborative culture among colleagues is an element of effective professional development.
(4) Effective professional development utilizes grade level/department professional learning communities
(5) Effective professional development involves visiting other schools.
(6) State and national conferences are an effective form of professional development.
(7) Professional Learning Community book studies are an effective form of professional development.
(8) Effective professional development sustains a consistency of focus over time.

(9) Effective professional development for teachers is university courses.
(10) An effective element of professional development is personal focused reflection.
(11) Effective professional development requires participants to be involved in the planning, implementing, and evaluating of programs.
(12) Effective professional development includes follow-up and support for transfer of learning to the school or classroom.
(13) Effective professional development focuses on curriculum and instruction.
(14) Effective professional development is research-based and built upon theory.
(15) Effective professional development includes coaching from a peer or mentor.
(16) An effective element of professional development is to have all-day and multiple session meetings over an extended period of time.
(17) An effective element of professional development for teachers is to conduct differentiated sessions based on career stages, with specialized training for aspiring, new, and experienced teachers.
(18) Effective professional development includes providing opportunities for shared problem-solving.
(19) Effective professional development is primarily school-based as opposed to district based.
(20) Effective professional development exposes teachers to actual practice than to descriptions of practice.
(21) Effective professional development focuses on instructional strategies.
(22) Effective professional development should only focus on a few concepts at one time.
(23) A prerequisite of effective professional development is that one must have good reason to believe that the change being introduced is itself of value.
(24) Effective professional development involves professional learning communities with sources outside of the school.
(25) An effective element of professional development is providing constructive feedback on instructional practice.
(26) An effective element of professional development is providing a mentor to new teachers.
(27) An effective element of professional development is the inquiry process.
(28) Effective professional development involves observing other teachers.
(29) Effective professional development links directly with day-to-day work in real schools and classrooms.
(30) Professional development should be primarily school based and integral to school operations.
(31) Effective professional development includes providing time, contexts, and support for teachers to think.
(32) Effective professional development is embedded in the specific content of the student curriculum.
(33) Effective professional development integrates examination of student learning using multiple sources of evidence.
(34) Effective professional development invests in the change process to impact student knowledge and skills.

(Brown & Militello, 2016)

Appendix B—Recruitment Materials

Initial Introductory Outreach Email Script Educators
(This will be sent 24 hours prior to the email containing the survey)

Subject Line: Invitation to participate in a survey on Professional Development

Dear xxxxx-

I am reaching out to you as a NYS Master Teacher Emeritus to see if you would be willing to participate in a small research study to support my graduate dissertation work at Syracuse University. As an experienced teacher that has participated in multiple years of professional development, you know the importance of having access to high quality professional learning opportunities. Unfortunately, it is well known amongst educators that not all professional development is created equal. However, there is a growing body of literature that highlights aspects of effective professional development. Most of these ideas have been generated from the exit surveys of teachers that have participated in various professional learning opportunities. I believe what is now lacking from this literature is teachers' views on what are now considered important aspects of professional development.

Aware that you have participated in multiple years of professional learning through the NYS Master Teacher Program, I am asking for your help. Within the next 24 hours, I will be sending you an email link to a survey that will ask you to share your perceptions of ideas found in research literature that are considered aspects of effective professional development. The email will have the subject line "Effective Professional Development Survey." While I know your time is precious, I hope you will be able to find 30-45 minutes to complete the survey. Your answers will help the community of individuals who work to facilitate professional learning for educators. The more that is known about teachers' preferences regarding professional learning, the more that can be done to create learning opportunities that meet the needs and desires of teachers.

Many thanks in advance for taking the time to complete this survey. While your participation is absolutely voluntary, the information you can provide is extremely valuable. My hope is that the results of this survey will ultimately be of great benefit to the professional learning field. If you have any questions regarding participation in this survey, please do not hesitate to reach out to me, or my advisor on this project, Dr. Qiu Wang. Our contact information is pasted below.

Thank you,

Dominick Fantacone
Graduate Student—Syracuse University

Student Investigator: Dominick Fantacone
Graduate Student in Science Education
School of Education—Department of Teaching and Leadership
Email: dafantac@syr.edu

Phone: 607-423-5133

Faculty Advisor on Project: Dr. Qiu Wang
Associate Professor in Measurement and Research Methodology
School of Education—Department of Higher Education
Email: wangqiu@syr.edu
Phone: 315-443-4763

Email Script for Educators Containing Survey Link
(This will be sent 1 day after the introductory email)

Subject Line: Effective Professional Development Survey

Dear xxxxx-

As I mentioned in my previous email, I am reaching out to see if you would be willing to participate in a small research study to support my graduate dissertation work at Syracuse University.

As a NYS Master Teacher emeritus and an experienced teacher that has participated in multiple years of professional development, you know the importance of having access to high quality professional learning opportunities. Unfortunately, it is well known amongst educators that not all professional development is created equal. However, there is a growing body of literature that highlights aspects of effective professional development. Most of these ideas have been generated from the exit surveys of teachers that have participated in various professional learning opportunities. I believe what is now lacking from this literature is teachers' views on what are now considered important aspects of professional development.

Aware that you have participated in multiple years of professional learning through the NYS Master Teacher Program, I am asking for your help. Below, I have provided an email link to a survey that will ask you to share your perceptions of ideas found in research literature that are considered aspects of effective professional development. I am requesting that you complete this survey in the next two weeks, if you choose to participate. While I know your time is precious, I hope you will be able to find 30-45 minutes to complete the survey. Your answers will help the community of individuals who work to facilitate professional learning for educators. The more that is known about teachers' preferences regarding professional learning, the more that can be done to create learning opportunities that meet the needs and desires of teachers.

A logistical piece: When you first click the link to access the survey, you will be directed to a welcome page. When you click continue, you will be provided with an electronic consent form. Please take time to review the information in the consent form. If you agree to the information in the consent form, you can click continue to proceed to the survey. You are welcome to print the consent form so you have the information. I have also attached the language from the consent form to this email so you can have it for your records. Please remember, you may end your participation in this research study at any time by closing the survey program.

Many thanks in advance for taking the time to complete this survey. While your participation is absolutely voluntary, the information you can provide is extremely valuable. My hope is that the results of this survey will ultimately be of great benefit to the professional learning field. If you have any questions regarding participation in this survey, please do not hesitate to reach out to me, or my advisor on this project, Dr. Qiu Wang. Our contact information is pasted below.

Link to the survey: https://tinyurl.com/SyrPDSurvey
PLEASE DO NOT SHARE THIS LINK WITH ANYONE

Thank you,

Dominick Fantacone
Graduate Student—Syracuse University

Student Investigator: Dominick Fantacone
Graduate Student in Science Education
School of Education—Department of Teaching and Leadership
Email: dafantac@syr.edu
Phone: 607-423-5133

Faculty Advisor on Project: Dr. Qiu Wang
Associate Professor in Measurement and Research Methodology
School of Education—Department of Higher Education
Email: wangqiu@syr.edu
Phone: 315-443-4763

Email Script for Educator: Follow-up Email
(this will be sent one week after the survey email)

Subject Line: Reminder_Effective Professional Development Survey

Dear XXXX-

I am reaching out to remind you of the invitation to participate in the Effective Professional Development Survey. If you plan to participate, and have not had a chance to complete the survey, I ask that you try to do so in the next week. I anticipate the survey taking 30-45 minutes to complete. I value the input you can provide regarding the aspects of effective professional development. If you have already completed the survey, many thanks for your time and the information you have provided.

While your participation is absolutely voluntary, the information you can provide is extremely valuable. My hope is that the results of this survey will ultimately be of great benefit to the professional learning field. If you have any questions regarding participation in this survey, please do not hesitate to reach out to me, or my advisor on this project, Dr. Qiu Wang. Our contact information is pasted below.

Link to the survey: https://tinyurl.com/SyrPDSurvey
PLEASE DO NOT SHARE THIS LINK WITH ANYONE

Thank you,

Dominick Fantacone
Graduate Student—Syracuse University

Student Investigator: Dominick Fantacone
Graduate Student in Science Education
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School of Arts & Sciences—Science Teaching
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Appendix C—Dissertation Q Set with Citations

Statement Label	Statement	Citation
(s1)	Effective professional development involves visiting other schools.	(Brown & Militello, 2016)
(s2)	Effective professional development involves observing other teachers.	(Brown & Militello, 2016)
(s3)	Effective professional development is research-based and built upon theory.	(Brown & Militello, 2016; Cochran-Smith & Lytle, 1999)
(s4)	Effective professional development utilizes data from teachers' actual practice as the starting point for their critical and systematic reflection.	(Guskey, 2003; Vanassche & Kelchtermans, 2016)
(s5)	A prerequisite of effective professional development is that a teacher believes that the change being introduced is valuable to their work.	(Brown & Militello, 2016; Vanassche & Kelchtermans, 2016)
(s6)	Effective Professional development programs include an explicit focus on specific content/subject matter.	(Blank,2010; Darling-Hammond et al., 2009; Desimone, 2009; Desimone et al., 2006); Dresner & Worley, 2006; Main et al., 2015)
(s7)	Effective professional development programs can help teachers deepen their knowledge and transform their teaching.	(Borko, 2004; Cochran-Smith & Lytle, 1999; Desimone, 2009; Main et al., 2015)
(s8)	Effective professional development requires participants to be involved in the planning, implementing, and evaluating of programs.	(Brown & Militello, 2016; Gravani, 2012)
(s9)	Effective professional development includes follow-up and support for transfer of learning to the school or classroom.	(Desimone, 2009; Flory et al., 2014; Main et al., 2015)
(s10)	Effective professional development includes coaching from a peer or mentor.	(Blank, 2010; Brown & Militello, 2016)
(s11)	An effective element of professional development is providing constructive feedback on instructional practice.	(Blank, 2010; Brown & Militello, 2016)
(s12)	Effective professional development allows teachers to experience learning rather than being passive learners.	(Desimone et al., 2002; Ebert & Crippen, 2010; Gravani, 2007; Jeanpierre et al., 2005; Wilson, 2013)
(s13)	Effective professional development includes teachers being treated as a colleague and professional by facilitators of professional development.	(Dresner & Worley, 2006)
(s14)	Effective professional development includes providing teachers opportunities to take on leadership roles.	(Desimone et al., 2002)
(s15)	Effective professional development includes opportunities for teachers to collaborate with experts.	(Cochran-Smith & Lytle, 1999; Deglau & O'Sullivan, 2006; Lieberman & McLaughlin, 1992)
(s16)	An effective element of professional development is to conduct differentiated sessions based on teachers' experience levels (e.g., pre-service teachers, new teachers, experienced teachers).	(Brown & Militello, 2016; Gravani, 2007; Giannoukos et al., 2015)
(s17)	Effective professional development focuses on pedagogy.	(Avalos, 2011; Cochran-Smith & Lytle, 1999; Desimone et al., 2002)
(s18)	A workshop facilitator who can establish a community around the work that is being done is crucial to the success of teacher learning within effective professional development.	(Borko, 2004)

(s19)	Active learning opportunities increase the effectiveness of professional development for teachers' instruction.	(Desimone et al., 2002; Garet et al., 2001; Gravani, 2012)
(s20)	Effective professional development that models instruction helps teachers to visualize how to implement their new learning in the classroom.	(Brown et al., 2014; Wilson, 2013)
(s21)	Effective professional development includes time to collaborate with peers.	(Brown & Militello, 2016; Fazio, 2009; Herrington et al., 2016)
(s22)	Effective professional development requires establishing a collaborative culture among colleagues.	(Brown & Militello, 2016; Lieberman, 1995)
(s23)	Effective professional development allows teachers to balance personal life situations (e.g., child care, possible financial and family issues, other teaching responsibilities).	(Giannoukos et al., 2015; Knowles, 1978; Vanassche & Kelchtermans, 2016)
(s24)	During professional development, teachers will go through stages in the change process and will have different needs/require different supports at different stages.	(Fetters, 2002; Giannoukos et al., 2015; Gravani, 2012; Lieberman & McLaughlin, 1992)
(s25)	During effective professional development, teachers are committed to learning when the program's goals and objectives that are job related and perceived as being immediately useful.	(Borko, 2004; Gravani, 2012; Lieberman & McLaughlin, 1992)
(s26)	Effective professional development considers that teachers' physical and psychological comfort are taken into account.	(Wilson, 2013)
(s27)	Effective professional development that is long-term/continuous allows teachers to learn more when compared to one-time professional development offerings.	(Desimone, 2009; Lieberman, 1995; Main et al., 2015)
(s28)	Activities within effective professional development are designed to help teachers better understand both what they teach and how students acquire specific content knowledge and skills.	(Ebert & Crippen, 2010; Guskey & Yoon, 2009)
(s29)	Professional development is more effective when it is part of the scheduled work day.	(Cochran-Smith & Lytle, 1999; Darling-Hammond et al., 2009)
(s30)	Effective professional development includes learning that aligns curriculum to standards.	(Blank, 2010; Desimone et al., 2002)
(s31)	Effective professional development that focuses on a particular teaching practice increases the likelihood of teachers' using that practice in their classroom	(Desimone et al., 2002; Main et al., 2015)
(s32)	Effective professional development includes an analysis of student work samples.	(Brown & Militello, 2016; Wilson, 2013)
(s33)	Effective professional development includes providing opportunities for shared problem-solving.	(Brown & Militello, 2016; Gravani, 2012)
(s34)	Effective professional development includes time for teachers to develop assessments.	(Blank, 2010; Darling-Hammond & McLaughlin 2011)
(s35)	Effective professional development involves teachers' grappling with student thinking and considering the implications for instruction.	(Darling-Hammond et al., 2009; Mak & Pun, 2015; Patton et al., 2015)
(s36)	Effective professional development includes resources and creative sessions similar to what is required by teachers in a classroom, so they can experience first what they are asked to put into practice.	(Ebert & Crippen, 2010; Gravani, 2007)
(s37)	Effective professional development engages teachers in concrete tasks of teaching, assessment, observation, and reflection that illuminate the processes of learning and development.	(Darling-Hammond et al., 2009; Darling-Hammond & McLaughlin 2011)

(s38)	Professional development is more-effective if there is participation of teachers from the same school, department, and/or grade.	(Blank, 2010; Brown & Militello, 2016; Desimone et al., 2002; Desimone et al., 2006)
(s39)	While professional development programs are needed to provide an initial vision for change, networks of colleagues can be the motivating factor that sustains the work for change over time.	(Dresner & Worley, 2006; Fazio, 2009; Lieberman, 1995; Still & Gordon, 2009)
(s40)	Effective professional development links directly with day-to-day work in real schools and classrooms.	(Brown & Militello, 2016; Main et al., 2015)
(s41)	Change/improvement strategies utilized within effective professional development are most effective when they are selected to meet teachers' needs.	(Fetters, 2002; Giannoukos et al., 2015; Gravani, 2012; Knowles, 1978; Lieberman & McLaughlin, 1992)
(s42)	School administrators promote models of effective professional development that consider the organizational context, culture, and climate in which teachers work.	(Barley & Pun, 2015; Drago-Severson, 2000; Kilbane, 2009)
(s43)	Administrative (e.g., principals) support of reform is important for the success of effective professional development.	(Barley & Pun, 2015; Fetters, 2002; Kilbane, 2009)
(s44)	Effective professional development utilizes activities that challenge teachers and promote their professional growth.	(Lieberman & McLaughlin, 1992)

Appendix D—Survey Instrument Part B

Most Identify With (+5)

(9) Effective professional development includes follow-up and support for transfer of learning to the school or classroom.	
(44) Effective professional development utilizes activities that challenge teachers and promote their professional growth.	

Least Identify With (-5)

(15) Effective professional development includes opportunities for teachers to collaborate with experts.	
(14) Effective professional development includes providing teachers opportunities to take on leadership roles.	

In considering the aspects of effective professional development that were included in this survey, do you feel there was anything missing that should be considered? If so, please list below:

In considering the placement of items on the score sheet, were there certain items that their placement posed a challenge for you because of the forced ranking caused by the limit in the number of items per column? If so, can you recall which items and explain below what the challenge was for you:

In thinking about the idea of "effective professional development", how would you define effective professional development?

How many years have you been teaching?

- 6-10 Years
- 11-15 Years
- 16-20 Years
- 21-25 Years
- 26+ Years

Have your views of professional development changed since you started teaching? If so, please describe this change below:

In considering the aspects of effective professional development that were included in this survey, do you believe if an administrator (like a principal) were given the same set of statements, the ranking would be similar to how a teacher would rank them?

- Yes
- No

Please explain why you selected Yes or why you selected No.

Which Grade Level(s) do you teach?

- K-2
- 3-5
- 6-8
- 9-12

Which subject area do you teach?

Which best describes the type of district your work in?

What is your gender?

- Female
- Male
- Non-Binary
- Prefer not to disclose

Which category below includes your age?

- 25 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- Age 65 or older
- Prefer not to say

What is your racial or ethnic identification?

- White
- Black or African American
- Latino or Hispanic
- American Indian or Alaskan Native
- Asian
- Native Hawaiian or other Pacific Islander
- From multiple races
- A racial or ethnic category not listed here
- Prefer not to say

If you selected "A racial or ethnic category not listed here", can you please specify in the box below your racial or ethnic identification:

Appendix E—R code

Code used to run analysis for science teachers:

```
Dom.data<-import.htmlq("Dom Dissertation Data File Science.csv")

statement44<-read.csv("Dom Dissertation Statements.csv", header=FALSE)
statement44$V1

######5 factors#
results1<-qmethod(Dom.data[[1]],cor.method="spearman",nfactors = 5,rotation = "cluster")
summary(results1)
loa.and.flags(results1)
#
scores <- cbind(results1$zsc_n, statement44$V1)
# Order the results by the scores of each factor:
for (i in 1:length(results1$loa)) {
  View(scores[order(scores[i], decreasing = TRUE), ],
       title = paste0("Order for f", i))
}

par(lwd = 1.5, mar = c(4, 4, 0, 0) + 0.1)
plot(results1)
abline(h = seq(from = 1, to = 44, by = 1), col = grey(0.2), lty = 2)

# Data frame of distinguishing and consensus statements:
format(results1$qdc, digits = 1, nsmall = 2)
```

Code used to run analysis for mathematics teachers:

```
Dom.data<-import.htmlq("Dom Dissertation Data File Math.csv")

statement44<-read.csv("Dom Dissertation Statements.csv", header=FALSE)
statement44$V1

######3 factors#
results1<-qmethod(Dom.data[[1]],cor.method="spearman",nfactors = 3,rotation = "cluster")
summary(results1)
loa.and.flags(results1)
#
scores <- cbind(results1$zsc_n, statement44$V1)
# Order the results by the scores of each factor:
for (i in 1:length(results1$loa)) {
  View(scores[order(scores[i], decreasing = TRUE), ],
       title = paste0("Order for f", i))
```

```
}

par(lwd = 1.5, mar = c(4, 4, 0, 0) + 0.1)
plot(results1)
abline(h = seq(from = 1, to = 44, by = 1), col = grey(0.2), lty = 2)

# Data frame of distinguishing and consensus statements:
format(results1$qdc, digits = 1, nsmall = 2)
```

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EDUCATION:

Ph.D. Science Education, Syracuse University, NY — Anticipated 2021
M.A.T., Adolescence Education in Biology, SUNY Cortland, NY — May 2012
M.B.A., Management and Leadership, Rochester Institute of Tech., NY — May 2002
B.S. Biological Sciences, Rochester Institute of Tech., NY — May 2001

PROFESSIONAL CERTIFICATIONS:

NYS Teacher Initial Certification in Adolescence Education (7-12) Biology, Biology Extension (5-8), and General Science (7-12)

ADMINISTRATIVE AND PEDAGOGICAL EXPERIENCE:

Assistant Director for Regional Operations (50%) — November 2013-Present
NYS Master Teacher Program—SUNY System Administration, NY

- Oversee the operations of the NYS Master Teacher Program at the 9 host SUNY campuses across New York State
  - Supervise the efforts of Regional Directors on campuses
  - Assist in the planning of regional professional development activities
  - Support campuses in meeting the vision and goals of the NYSMTP
  - Resolve issues that arise on campuses during program implementation
- Serve as the liaison between Regional Directors at the 9 campuses and the Executive Director at SUNY System Administration
- Develop the strategic goals, program guidelines, and program requirements to meet campus' needs as aligned to our logic model, in collaboration with the Executive Director
- Coordinate Professional Learning Teams across NYS the function as a method for delivering professional development to teacher.
  - Provide trainings on Professional Learning Teams to NYS Master Teachers across the state
  - Create an annual Directory of Professional Learning Teams
  - Support teacher groups that experience conflict with other members of their group
- Participate in annual recruitment process
  - Conduct recruitment information sessions around the state for perspective teacher applicants
  - Coordinate application review process in multiple locations across NYS
  - Review teacher applications and assist in selection of teachers for the program

Central New York Regional Director (50%) — July 2013-Present
NYS Master Teacher Program—State University of New York College at Cortland, NY

- Facilitate professional development opportunities for NYS Master Teachers in the Central New York Region, a 5-county region with teachers representing 26 individual districts
  - Build relationships with various education stakeholders in NYS that can provide training for teachers
- Administer all operations of the program at SUNY Cortland
  - Secure all contracts from vendors
  - Execute all purchasing through Red Dragon Depot and process payments of invoices.
  - Establish and monitor annual budget utilize Oracle's Business Intelligence
- Coordinate the Central New York Region's recruitment and interview of teachers for the NYSMTP
- Assist teachers in creating and implementing short- and long-term growth goals.

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Adjunct Lecturer August 2012-Present
State University of New York College at Cortland, NY

- Taught science methods at both the undergraduate and graduate levels
- Instructed introductory biology lab courses and microbiology lab courses at both the undergraduate non-majors and majors level
- Created and implement lessons and lab exercises, write syllabi and establish learning objectives
- Developed assessments to gauge students' understanding of major concepts
- Executed classroom management by developing a strong rapport with students

Middle School Science Teacher Summer 2013
OCM BOCES, NY

- Instructed students in 8th grade physical science class
- Utilized minimal resources to create a rich remedial program for students that were unsuccessful in passing this subject during the normal school year
- Tracked student improvement over the summer by creating a pre- and post-assessment
- Lessons created based on the outcomes from pre-assessment resulted in all students showing positive improvement

Substitute Teacher December 2009-December 2013
Homer Central School District, NY

- Served as an on-call substitute throughout all grade levels in a variety of content areas for the district

BUSINESS MANAGEMENT EXPERIENCE:

Business Manager 2009-2012
Foster Custom Kitchens, Inc, NY

- Lessons created based on the outcomes from pre-assessment resulted in all students showing positive improvement
- Executed day to day business functions of small design firm including accounts payable, accounts receivable, payroll tasks, human resource functions
- Created and maintained annual budget and financial statements for the company
- Established and continually evaluated relationships with vendor accounts to help attract and maximize revenue streams
- Developed a strategic business plan in 2010 for the company and worked with lender to refinance the debt of the company to assist with cash flow problems

Business Manager 2006-2009
Class Act Kitchen and Bath, NY

- Created and maintained annual budget, cash flow analysis, labor cost analysis, breakeven analysis—all new tools for the company
- Developed and implemented a three-year business plan to secure funding to refinance the debt of the company
- Performed human resource functions for company including hiring, retention, and dismissal of employees, as well as payroll and benefits

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- Oversaw the training of new employees and provided continuing education to all employees to maximize output and performance
- Arranged all corporate marketing including creating and implementing a new marketing strategy using print, radio and television media
- Acted as an integral part of attaining new clients and retaining repeat clients by working side by side with the sales and design teams
- Implemented customer satisfaction initiatives and quality control efforts
- Took leading role in securing financing and opening a second location for the company in May of 2006

Store Manager 2004-2006
Radio Shack Corporation, NV

- Executed the day-to-day operations of a retail store including performing inventory management functions, overseeing human resource functions including interviewing and hiring, payroll entry, and facilitating the training of new employee
- Promoted from Assistant Manager to Store Manager within three months of being hired
- Met or surpassed sales goals set by district manager on a regular basis

GRANTS FUNDED:

Office of Naval Research—"Engaging the Next Generation STEM Naval Workforce: Using Communities of Practice to Build Teacher Capacity" (with Pagano, A.M.). $610,000, 2018-2021.

SUNY Cortland Academic Program Innovation Grant—"Cultivating Student-centered Pedagogies to Enhance Engagement" (with Klein, B., Pagano, A.M., Timberlake, M., Maricle, K., Abramo, A.). $10,100, 2016-2017.

PRESENTATIONS, PROCEEDINGS, AND PAPERS:

Radloff, J., **Fantacone, D**., Pagano, A.M. *Examining master teachers' tensions with transitioning to remote STEM instruction* (January 2021). Paper accepted for presentation at the Association for Science Teacher Education.

Radloff, J., **Fantacone, D**., Pagano, A.M. (October 2020) *Characterizing secondary STEM master teachers' instructional strategies when transitioning to remote settings*. Paper accepted for presentation at the Northeast Association for Science Teacher Education.

Radloff, J., **Fantacone, D**., & Pagano, A.M. (Journal submission in progress). *Examining master teachers' tensions with transitioning to remote STEM instruction*.

Radloff, J., **Fantacone, D**., & Pagano, A.M. (Journal submission in progress). *Characterizing secondary STEM master teachers' instructional strategies when transitioning to remote settings.*

Fantacone, D., & Wang, Q. (Journal Submission in Progress). Examining STEM teachers' views of the characteristics of effective professional learning: A Q-methodology

Fantacone, D., & Smith, M. (November 2019). *Getting started with science notebooks.* Presentation at Science Teachers Association of New York State Annual Conference, Rochester, NY.

Fantacone, D. (October 2019). *Utilizing mass media in the science classroom*. Presentation at New Jersey Science Convention, Princeton, New Jersey.

Fantacone, D., & Smith, M. (November 2018). *Utilizing mass media in the science classroom*. Presentation at Science Teachers Association of New York State Annual Conference, Rochester, NY.

Fantacone, D. (April 2018). *Designing and facilitating professional learning teams*. Presentation for Finger Lakes Region Master Teacher Program, Geneseo, New York

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Fantacone, D. (March 2018). *Designing and facilitating professional learning teams*. Presentation for Mohawk Valley Region Master Teacher Program, New Hartford, New York

Fantacone, D. (February 2018). *Designing and facilitating professional learning teams*. Presentation for Central New York Region Master Teacher Program, Cortland, New York.

Fantacone, D. (January 2018). *Designing and facilitating professional learning teams*. Presentation for Capital Region Master Teacher Program, Albany, New York.

Fantacone, D. and Smith, M. (November, 2017). *Literacy in an elementary science classroom*. Presentation at Science Teachers Association of New York State Annual Conference, Rochester, NY.

Pagano, A.M., **Fantacone, D**., & Reynolds, M. (October 2016). *A workshop on communicating science*. Pennsylvania State University, Harrisburg and State College, PA.

Thomas, A. B., Pagano, A.M., **Fantacone, D**., & Lachance, A. (2016). Sharing perspectives and experiences: Panel remarks made at the TeachNY Central New York Regional Engagement Sessions, May 25, 2016, State University of New York College at Cortland. *Excelsior: Leadership in teaching and learning*, *11*(1), 1-9.

Thomas, A. B., Pagano, A.M., **Fantacone, D**., & Lachance, A. (May 2016). *TeachNY: Sharing perspectives and experiences.* Presentation at Central New York Regional Engagement Session SUNY Cortland, Cortland, NY.

Fantacone, D., & Pagano, A.M. (December 2015). *PLT 201.* Presentation for Central Region Master Teacher Program, Cortland, NY.

Fantacone, D., & Pagano, D. (December 2014). *PLT 201.* Presentation for Long Island Region Master Teacher Program, Stony Brook, NY.

Fantacone, D. (November, 2014). *An Introduction to Professional Learning Teams*. Presentation for Mid-Hudson Region Master Teacher Program, New Paltz, NY.

Fantacone, D., & Pagano, A.M. (November 2014). *Keeping it current: Managing the flow of scientific information to students*. Presentation at STANYS Conference, Rochester, NY.

Fantacone, D., & Pagano, A.M. (November, 2014). *An Introduction to Professional Learning Teams*. Presentation for Long Island Region Master Teacher Program, Stony Brook, NY.

Fantacone, D., & Pagano, A.M. (November, 2013). *Bringing relevancy back to the science classroom*. Presentation at STANYS Conference, Rochester, NY.

Fantacone, D. (July 2013). *Bioenergy and bioproducts education*. Presentation at Cornell University, NY.

Fantacone, D. & Pagano, A.M. (October 2012). *Bioenergy and bioproducts education in the classroom*. Presentation at Noyce Northeast Conference 2012, Boston, MA.

Pagano, A.M., **Fantacone, D**., & Smith, S. (October 2011). *Bringing space down to earth! Teaching secondary science using NASA materials*. Presentation at Noyce Northeast Conference 2011, Philadelphia, *PA*.

HONORS AND AWARDS:

Excellence in Research, Scholarship, and Outreach, SUNY Cortland 2018
Awarded in recognition of grant received through the Office of Naval Research

Service Award for Outstanding Contributions to the STANYS Section, 2015
Science Teachers Association of New York State
Awarded to one member in the Southern Section each year that makes a significant contribution to the organization

Excellence in Research, Scholarship, and Outreach, SUNY Cortland 2015
Awarded in recognition in research activities on Problem-Based Learning and Science Communication for faculty at SUNY Cortland

Dominick A. Fantacone

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Noyce Graduate Scholar, SUNY Cortland 2011-12
Scholarship Awarded to graduate students pursuing a teaching career in a STEM or Economics field

PROFESSIONAL ORGANIZATIONS AND AFFILIATIONS

NYS Science Education Consortium Member January 2018-Present
Chair of the Communications Committee and Newsletter Editor since 9/2019
Association for Science Teacher Education December 2017-Present
Attended annual conference in 2018; Conference proposal accepted for 2021
National Science Teaching Association May 2015-Present
American Association for the Advancement of Science May 2012-Present
Science Teachers Association of New York State September 2012-Present
Biology Subject Area Representative for the Southern Tier Region from 9/2012-6/2019; Webmaster for Southern Tier Region since 9/2014; Member of the Board of Directors since 7/2015; President 2020-21; President Elect 2019-20; Vice President 2018-19

PROFESSIONAL ACTIVITIES

SUNY Institute for Academic & Innovative Leadership (SAIL) Winter Leadership Retreat, Carey Institute 2018
The SAIL Institute seeks to advance understanding and development of the next generation of leaders in higher education
Middle States Commission on Higher Education, Syracuse University 9/2016-3/2017
Graduate student representative on the team that was responsible for writing the section of report for the self-study that had to deal with Middle States Standard 1
SUNY Cortland Center of Innovation for Education, SUNY Cortland 2014-2016
Committee Member, Focused on Project-Based Learning and Science Communication
State University of New York TeachNY Leadership Task Force, 2014-2016
Crucial Conversations Training, SUNY Cortland 2016
Alan Alda Center for Communicating Science Summer Boot Camp & Train the Trainer Workshop, Stony Brook University 2015
Alan Alda Center for Communicating Science Summer Institute, Stony Brook University 2014