

A Comparative Review of the Literature on Pakistani Science Teachers' Professional Development

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ABSTRACT

Pakistan, like many other countries of the world, has continually been criticized for its unproductive professional development (PD) policies and practices for teachers due to low student achievement in science disciplines. A good portion of science teachers (62%) in Pakistan was found to be uncomfortable in teaching the scientific concepts (National Education Assessment System [NEAS], 2014) and PD programs are failing to address this issue. There is a need to reconstruct the operationalized knowledge of PD for Pakistan to expand the ways of knowledge creation, examination, authentication, and distribution. This also implies the need to review the current western literature on PD designs and practices to explore the ways of addressing the issues of Pakistani PD programs. With this purpose in mind, the current study set out to search the comparative understanding of science teachers' PD learning and experiences in Pakistan. The study was carried out to review the literature on science teachers' PD learning and experiences in the Western context (The US and European countries) while comparing it with the situation of Pakistani science teachers' PD practices. This seeks to address the critical questions of how to increase the effectiveness in Pakistani PD practices.

KEY WORDS: professional development; science; teachers; Pakistan

INTRODUCTION

Teacher professional development (PD) refers to those programs designed to assist teachers in improving their knowledge, skills, and motivation to increase learning and student achievement (Melville and Yaxley, 2009; Whitworth and Chiu, 2015). Teachers' role in the inception, implementation, and evaluation of PD is central to successful and sustained PD programs (Luneta, 2012). According to Hargreaves and Shirley (2012), meaningful PD relies on the individual teacher realizing a need to think and work differently. It can be implemented through participation in formal PD programs or by becoming a member of professional learning communities. For in-service science teachers, PD learning offers varied opportunities to build capacity for informed decision-making, transformation in their instructional practices and ultimately, student outcomes (Smith and Lindsay, 2016).

Internationally, it is well accepted that PD for science teachers is critical for the success of science education. However, PD activities are under constant criticism by researchers as teachers largely fail to apply the intended goals of those activities in their classrooms, resulting in little or no improvement in the student learning outcomes (Buczynski and Hansen, 2010). The findings from Programme for International Student Assessment, Trends in International Mathematics and Science Study (TIMSS), and in Eurydice studies of European countries (2007–2009) highlight that regardless of the PD programs, the traditional approaches

of teaching science are still dominant in schools in Europe (Scheerens, 2010). The situation is even worse in Africa and in many countries in Asia, where science teachers lack sufficient resources, rejects research-based changes to the methodology, and is characterized by an overall reluctance to accept change.

Pakistan, like many other countries of the world, continually receives criticism for its unproductive PD policies and practices for teachers due to low student achievement in science. A good portion of science teachers (62%) in Pakistan was found to be uncomfortable with teaching the scientific concepts (NEAS, 2014) and PD programs are failing to address this issue properly. Pakistan must shift the way PD is examined and implemented to reconstruct the operationalized knowledge of PD effectively. This will result in the authentic improvement of professional learning. Another useful approach is to review the current western literature on PD practices and apply those practices to current Pakistani PD programs. With this purpose in mind, the current study set out to search the comparative understanding of science teachers' PD learning and experiences in Pakistan. The study includes a comparative review of the literature on science teachers' PD learning and experiences in the Western context (The US and European countries) with Pakistani science teachers' PD practices with the objective of addressing critical questions of how to increase the effectiveness of Pakistani PD practices.

METHOD OF THE LITERATURE REVIEW

For the literature review, ScienceDirect, ERIC, and EBSCO hosts were used as the main search engines, including a rigorous document search on Google and Google Scholars. The term PD was held constant due to its centrality to the review. A variety of terms such as science teacher learning, learning effectiveness, science teacher practices, science teachers' needs, science teachers' experiential challenges, learning challenges and issues, and science teachers' strategies, with both British and American spellings were used to search the databases. For the Western contexts, research articles published in peer-reviewed journals between 2001 and 2018 were used as the primary source of the review, while some books and book chapters served as a secondary source. For the Pakistani context, the literature selection included only research articles, reports, and official documents published in English that contained information on Pakistani science education. This review was limited to the literature on science teachers' PD efforts at the K-12 school level for both contexts.

The following research questions were addressed:

1. What is the focus of the literature on science teachers' PD learning and experiences in the Western context? How do the different features of PD learning and experiences support or impede PD effectiveness?
2. What is the focus of the literature review on science teachers' PD learning and experiences in the Pakistani context? How do the different features of PD learning and experiences support or impede PD effectiveness?
3. What implications do the information gathered from the literature review have for Pakistani policymakers and researchers for developing research programs in studying PD programs and designing effective PD programs?

The first part of the review considers the science teachers' PD learning and experiences in the Western context. The second part of the literature review concentrates on Pakistani science teachers' PD learning and experiences. The third part of the literature review, discussion and conclusion compares the Pakistani science teachers' PD learning experiences with that of the Western context and concludes with implications for how to improve PD learning experiences for Pakistani stakeholders.

SCIENCE TEACHERS' PD LEARNING AND EXPERIENCES IN WESTERN CONTEXT

Science teachers' PD is viewed as an ongoing learning experience that spans the entirety of the teaching profession (Desimone, 2009; Guskey, 2002). It includes activities from formal, highly structured topic-specific seminars provided on PD days to everyday, informal discussions between science teachers. Likewise, PD is the primary approach that schools use to ensure that teachers are continually strengthening their practices with research-based methods aimed improving at their pedagogical content knowledge (PCK), nurturing critical thinking, and increasing problem-solving skills (Desimone et al., 2002). The purpose of an effective PD program is to

bring about positive changes in the participants' professional life so that they can interact with their social and cultural realities (Buczynski and Hensen, 2010). The most effective PD practices are those that focus on science teachers as individuals and results in sustainable changes in teachers' learning and practice (Desimone et al., 2002). These PD practices require that science teachers be participants in the identification of their learning needs. Effective PD can result in changing science teachers' practices by enhancing their professional experiences, personal epistemologies, openness, and willingness for change (Asghar et al., 2012; El-Hani and Greca, 2013; Guskey and Yoon, 2009; Lee and Buxton, 2013).

Teacher learning outcomes are shaped through PD structure, design, and objectives. An extensive body of the literature was reviewed to determine the following: Impacts of PD on science teacher learning and experiences (Bell and Odom, 2012; Eilks and Markic, 2011; Opfer and Pedder, 2011; Posnanski, 2010); science teachers' growth and change (Akiba, 2012; Banilower et al., 2007; Goodnough, 2010; Melville and Yaxley, 2009; Ramlo, 2012; Tan and Nashon, 2013); positive relationship with instructional practices (Beamer et al., 2008; Desimone et al., 2002; El-Hani and Greca, 2013; Kazempour, 2009; Lee and Buxton, 2013; Smith, 2015); reflective practices (Capobianco and Feldman, 2006; Mamluk-Naaman and Eilks, 2012; McNicholl and Blake, 2013; Saylor and Johnson, 2014; Tang and Shao, 2013); and science teachers' self-perception (Allen and Penuel, 2015; Lustick, 2011; Mikelskis-Seifert and Duit, 2013; Mokhele and Jita, 2010; Torff and Byrnes, 2010).

Researchers have also measured the impact of PD learning activities on instructional effectiveness by measuring student outcomes. For instance, students' classroom achievements were evaluated by assessing their attitudes toward science learning (Adamson et al., 2013; Diamond et al., 2014; Foster et al., 2013; Herman et al., 2013; McNeill and Knight, 2013; Oliveira et al., 2013; Santos and Oliveira, 2006; Sinclair et al., 2010; Sullivan-Watts et al., 2013).

To make PD practice relevant, useful, and meaningful, it is essential to consider the positive experiences of teachers (Guskey, 2002; Sexton et al., 2013). Presently, western literature focuses on the specific ways wherein science teachers learn and experience during PD activities and the ways in which PD programs support teachers' changing attitudes and beliefs toward science teaching (Imants, 2002; Park et al., 2015; Visser et al., 2013).

A Brief Literature Review on Learning and Experiences of Science Teachers in the Western Context through PD

Researchers have asserted that evaluating the effects of PD programs on science teachers' learning is a complex process (Allen and Penuel, 2015), which varies across the context of the school environments (Luft and Hewson, 2014). According to Garet et al. (2001), a majority of researchers agreed on what establishes effective PD activities. Despite this, there is only limited literature available on the issue as to how these activities are translated into teachers' professional learning

(Loughran, 2013; Opfer and Pedder, 2011; Smith and Lindsay, 2016). The literature shows that there is no singular model that demonstrates best practices of PD that affect teachers' learning experiences (Lustick, 2011). However, to understand how science teachers learn, it is essential to investigate multiple contexts and factors in and with which they work (Borko, 2004).

Active learning experiences

Five features of effective PD learning and experiences have been commonly identified through research studies, these include: Focus on content, active learning, coherence, sufficient duration for practice, and reflection on PD learning experiences (Desimone, 2009; Guskey, 2002, Hynds et al., 2011; Tytler et al., 2001; Zientek, 2014). Similarly, several other researchers have included additional features of PD learning experience to the list. A synthesized view of different features of science teachers' PD learning and experiences, along with an operational definition of each feature is briefly provided in Table 1 and explained subsequently.

The literature on effective PD learning and experiences gave special emphasis to "active learning" which is based on the view of describing learning wherein the learner interacts

with the information and experiences (Garet et al., 2001). According to Desimone et al. (2002) and Saylor and Johnson (2014), effective PD learning and experiences entail active participation of science teachers in the PD process. Active learning experiences have a positive impact on teachers' practices through building their motivation, reflective thinking, personal epistemologies, attitude change, openness, and willingness to change (Akiba, 2012; Santos and Oliveira, 2006). Furthermore, active learning has the potential to result in more sustained change compared to other forms of learning.

Knowledge and belief construction

The evaluation of changes in science teachers' beliefs as a result of their participation in PD is a complex process and consists of interactions between PD learning, school contexts, and teachers' beliefs of science (Deniz and Akerson, 2013; Gao and Wang, 2014; Kazempour and Amirshokoohi, 2014; Posnanski, 2010). Research studies suggested that science teachers' existing ideas, beliefs, experiences, concerns, interest, and feelings toward PD programs are important criteria to consider in the development of effective PD activities (Afalo, 2013; Dare et al., 2014; Lotter et al., 2013).

Table 1: A synthesized review of the literature on science teachers' PD learning and experiences in the Western context

Features	Key findings(s)	Contributed scholar(s)
Active learning experiences	PD experiences provided to science teachers have an impact on science teachers' instruction approaches	Akiba, 2012; Desimone et al., 2002; Garet et al., 2001; Greene et al., 2013; Saylor and Johnson, 2014; Smith and Lindsay, 2016
Knowledge and beliefs construction	Science teachers' PD knowledge construction depends on their existing knowledge and beliefs	Allen and Penuel, 2015; Banilower et al., 2007; Berry et al., 2009; Crippen, 2012; Heck and Crawford, 2004; Holbrook et al., 2014; Lotter et al., 2013; Torff and Byrnes, 2010; Zwiap and Benken, 2013
Learning needs	What they already know and what they need to learn should be emphasized and improved on	Bernhardt, 2015; Nir and Bogler, 2008; Petrie and McGee, 2012; Ramlo, 2012; Roseler and Dentzau, 2013
Follow-up experiences	Effective PD programs contain follow-up experiences with multiple interactions	Antoniou and Kyriakides, 2013; Coenders et al., 2010; Eilks and Markic, 2011
Teacher research	Teachers learn through their action research opportunities to make an informed decision about instruction	Baumfield, 2007; Capobianco and Feldman, 2006; Corte et al., 2013; Harnett, 2012; Mamluk-Naaman and Eilks, 2012; Rathgen, 2006
Reflective practices	Examining of current and past professional practices and improving future practices through problem-solving strategies	Beamer et al., 2008; Bocala, 2015; Faber et al., 2014; Henze et al., 2009; Mamluk-Naaman and Eilks, 2012; Muir et al., 2010; Van Driel et al., 2001
Communities of practice	The activities of professionals such as coaching, teaming, partnerships, and other collective efforts have positive impacts on both instructional practices and student achievements	Akiba, 2012; Boyle et al., 2004; Cox-Petersen et al., 2005; El-Hani and Greca, 2012; Eilks and Markic, 2011; Goodnough, 2010; Howe and Stubbs, 2003; Ngcoza and Southwood, 2015; Owston et al., 2008; Patton et al., 2013
Leadership and organizational support	School principals, through their deliberate actions, need to identify, allocate, and support resources for teachers' professional learning	Buczynski and Hansen, 2009; Hobbs, 2012; Imants, 2002; Lovett and Cameron, 2011; Masuda et al., 2013; Oliveria et al., 2013; Opfer and Pedder, 2011; Rhodes and Beneicke, 2002; Sandholtz and Ringstaff, 2016; Whitworth and Chiu, 2015
Participation experience	Positive teachers' experiences of participation make PD learning relevant, useful, and meaningful	Guskey, 2002; Kazempour and Amirshokoohi, 2014; Kwakman, 2001; Lator and Abawi, 2014; Lustick, 2011; Mikelskis-Seifert and Duit, 2013; Nielsen, 2012; Sexton et al., 2013; Roux, 2013; Saunders, 2012; Seidel et al., 2011; White et al., 2010

PD: Professional development

There is a growing consensus among researchers that PD programs must emphasize CK and PCK to create highly effective PD learning experiences. Researchers have used PCK as an indicator of science teachers' learning after PD activities (Baniower et al., 2007; Garet et al., 2001; Zwiép and Benken, 2013).

Learning needs

Another crucial element to be considered in PD learning and experience is to match the PD programs with science teachers' learning needs. Science teachers' learning needs can be explored by placing focus on needs during the PD design and implementation. A major shortcoming noted by researchers who have studied PD programs for science teachers is that many PD programs fail to consider factors such as teachers' views, perceptions, and needs (Capobiano et al., 2006; Hermann, 2013; Holbrook et al., 2014; Kazempour and Amirshokohi, 2014).

Follow-up experiences

The amount of feedback and continued support offered to science teachers is also critical in the effectiveness of PD programs (Bernhardt, 2015). To ensure effective PD learning and experiences, PD developers are expected to set explicit teacher learning goals. There is a need to support science teachers' implementation of PD learning and assess them through follow-up activities to ensure that science teachers apply their PD learning and experiences (e.g., Antoniou and Kyriakides, 2013; Boyle et al., 2004). By engaging in such follow-ups, a coherence between the PD designs, instructional practices, and learning environment is established (Coenders et al., 2010; Eilks and Markic, 2011).

Teacher research

Teachers who inform and improve on their practices conduct teacher research or action research. It is predominantly considered to be a Western concept as a means to empower science teachers who want to increase knowledge about their own practices (Baumfield, 2007; Capobianco and Feldman, 2006; Harnett, 2012). The core conceptions of teaching significantly change when teachers engage in action-related research activities. This job-embedded approach engages teachers in meaningful and purposeful ways during and after PD and brings about effective professional learning in teachers (Corte et al., 2013). Different studies have emphasized that research-based PD experiences can influence the motivation of science teachers. Likewise, their action-research or participatory experiences can help them in their transition from a guided experience to freedom, making them feel useful and motivated (Faber et al., 2014). Their voices, viewpoints, and experiences as researchers empower them to play active roles in PD learning (Capobianco et al., 2006).

Reflective practices

Reflective practices involve the mental process of reflection and are considered to be a STRONG critical feature of PD learning and experiences. Through reflective practices, science teachers can effectively increase their competence to reflect critically on both the curriculum framework and the

circumstances in which they have to work (Mamlok-Naaman and Eilks, 2011). Further, reflective practices have been recognized as a popular feature that aids the understanding of PD, empowerment, and decision-making, as well as students' outcomes (Bocala, 2015; McCullagh, 2012; van Driel et al., 2001). Teachers can personalize their professional learning and experiences through reflective research practices (Corte et al., 2013; Çimer and Paliç, 2012).

Communities of practices

PD learning through the community of practices have been found to result in positive practice outcomes among science teachers (Howe and Stubbs, 2001; Kazempour and Amirshokohi, 2014; Sexton et al., 2013; Tang and Shao, 2014). When science teachers work as members of professional learning communities, their PD learning and experiences surpass participating in a single PD program; it is continuously shaped through social interactions (Boyle et al., 2004; Eilks and Markic, 2011). Vázquez-Bernal et al. (2012) mentioned, "teachers do not easily change their conceptions, and even less so, their educational practices" (p. 338). Thus, teachers need to continue to learn with the emotional support of a community of practice to gain a solid knowledge of the content (McNicholl and Blake, 2013).

Leadership and organizational support

In past few decades, an emphasis has been placed on the role of leadership and organizational support in building the capacity of the science teacher workforce during PD (Buczynski and Hansen, 2009; Imants, 2002; Opfer and Pedder, 2011; Sandholz and Ringstaff, 2016; Whitworth and Chiu, 2015). School leaders have a central role to play in supporting PD learning and experiences through developing teacher leadership and cultivating learning communities. Different organizational conditions and the availability of resources can also produce contexts that allow teachers to benefit more from PD learning opportunities.

Participation experiences

Teacher's participation in PD and experiences is considered to be a critical feature of teacher's learning and change. A successful PD program helps teachers acquire meaningful experiences and enables them to implement new ideas in schools (Baniower et al., 2007; Kazempour, 2009). However, participation in different PD experiences is embedded in temporal flows and sometimes stand out as disruptive or unmotivated actions (Daughbjerg et al., 2015). Studies have shown that science teachers' learning and experiences are evolving in specific PD situations. These meaningful experiences are, mostly, based on teachers' attitudes toward PD. Those teachers who are intensely motivated to attend the PD programs are likely to learn and change after participation.

Issues Observed in the Effectiveness of PD Programs in the Western Context

The research identified a number of ineffective features of PD programs for science teachers' learning and experiences. These included fragmentation, lack of implementation, and lack of teacher-centeredness (Lustick, 2011). For many teachers,

learning was perceived as a general activity instead of being a concept building or a discipline-specific activity (Zhang et al., 2015). Thus, the sustainability of PD learning and experiences become a challenge. Most PD programs appear to use traditional approaches that are not helping teachers revise what or how to teach (Borko, 2004; Wallace, 2013). Loucks-Horsley et al. (2009) stated that most PD programs do not feature a well-designed and continuous support system and are incapable of effectively addressing science teachers' learning needs. Because teachers' racial, historical, and curricular perceptions and challenges of participation in PD learning are not taken into account in the design, implementation, or improvement of the programs (Atwater et al., 2013); these programs can be ineffective. Similarly, some PD programs did not take the attitudes of science teachers into consideration (Boyle et al., 2004; Maskit, 2013; Torff and Byrnes, 2011).

Science teachers also perceive PD as fragmented, confusing, and unrelated to the issues they have regarding instructional practices (Lieberman and Mace, 2008). Current PD practices are imposed on teachers, reducing their power to choose their own objectives and methods, thus weakening their professionalism and efficacy. This leaves teachers to act as specialists, simply implementing someone else's design (McCullough et al., 2000) rather than being able to apply authentically what they have learned.

The literature on PD learning and experiences of science teachers in this paper can be categorized in two areas: (a) The fundamental features of science teachers' PD learning and experiences and (b) the organizational features of leadership. The fundamental features of science teachers' PD learning and experiences include experiences of active learning, participation, follow-up, collaboration, teacher research, and reflective practices. The organizational features of leadership, on the other hand, comprise a community of practices, support, and follow-up experiences. Features from those two categories are interwoven, and ultimately together, they influence PD programs' effectiveness.

Science Teachers' PD Learning and Experiences in Pakistani Context

The current practices of science teachers' PD in Pakistan are provided through a single workshop or at best, a series of sessions. Teachers in public sectors utilize the traditional Cascade model to instigate PD learning. Most of the PD programs emphasize the effectiveness of teachers by stressing the technical aspects of their profession (Ali, 2011). This section of the review explores the PD learning and experiences of science teachers in Pakistan, which is segregated into two subsections. The first section focuses on providing a brief background of the Pakistani PD structures and reform efforts for enhancing science teachers' learning while exploring the effectiveness of PD. The second section concentrates on the exploration of relevant literature that focuses on different facets of science teachers' learning and experience, and challenges associated with PD programs' effectiveness.

Background and structure

Pakistan's independence in 1947 initiated various reform efforts to bring about quantitative and qualitative changes in science teachers' learning and experiences. In 1950, science as a subject was offered in primary and middle schools. In 1959, the Pakistan Government began focusing on science teaching and recommended science as a compulsory subject for Grade Levels 6 through 8 (Iqbal and Mahmood, 2000). Several of the past educational policies (1959–2009) have shifted the emphasis from the teaching of science at the school level to of the importance of science and technology education in the country (Government of Pakistan, 2009). One of the most significant efforts for promoting the quality of science teaching at the national level came in 1984 with the help of the Asian Development Bank and Organization of the Petroleum Exporting Countries with the implementation of Science Education Projects (SEP). The government initiated this unique institutionalized effort to improve PD strategies for science teachers' professional learning. Through this effort, providing laboratory resources, school equipment, revising science curricula, and providing PD to science teachers enhanced the basic capacities of institutions.

The National Institute of Science and Technical Education (NISTE) was established in 2004 with the purpose of creating awareness among stakeholders for the development of science teaching skills. NISTE organized more than 500 PD programs between 2005 and 2008 on the discipline of science, mathematics, computer, and technologies for technical training. The institute trained 2603 science and technical teachers during the first 4 years of establishment. These PD programs provided an opportunity for science teachers to expand, learn new information, and share their knowledge, expertise, and experiences (Government of Pakistan, 2009). NISTE, between the years 2009–2012, implemented the project for the promotion of student-centered and enquiry-based (SCIB) science education. As a part of this project, a revised version of the national curriculum for science was introduced and new PD models based on SCIB science lessons were included in the study.

For instance, in the Punjab Province of Pakistan, significant changes took place regarding science teachers' PD under the SEP-1 and SEP Phase-II (1999-2007). Because of these initiatives, the emergence of 71 Regional Training Centers, 302 multi-purpose laboratories and 298 mathematics resource rooms were provided at the secondary level. To improve capacity, around 28,000+ heads of schools and science teachers' PD training in the subject of physics, chemistry, biology, mathematics, general science, and computers were implemented. Furthermore, 43 science teachers received foreign training in Australia and Malaysia for 5 weeks (Government of the Punjab, 2012). In 2004, the directorate of staff development (DSDs) was established as an apex organization to monitor the public-sector education scheme through a framework of continuous PD to ensure quality learning among science teachers. Along with the DSDs,

different public sector institutions such as the University of Education, Institute of Educational Research, and Provincial and Regional Institutes of Teacher Education provided different types of science teacher in-service PD training at elementary and secondary levels.

A Brief Literature Review on PD Learning and Experiences of Science Teachers in Pakistan

Studies conducted in Pakistan revealed that professional learning outcomes are produced through several effects such as socioeconomic, spiritual, and collective structures of individuals (Pardhan, 2005). According to these researchers, becoming an effective science teacher in Pakistan depends on the acquisition of reflective skills and pedagogical knowledge through personal learning experiences, support, and training received from other professionals. A synthesis of key features and major findings of research on Pakistani science teachers' learning experiences through PD are presented in Table 2. A brief description of each of those PD programs' key features and major findings also follows.

Knowledge and beliefs construction

Teachers' personal knowledge and beliefs, along with professional pedagogical knowledge, could influence PD practices. Beliefs about learning and teaching science are developed through different sources like teachers' personal experiences as students and professional experiences as science teachers (Begum, 2012; Mahmood, 2013). Different researchers in Pakistan recommended that for adequate development of PD programs, science teachers' existing ideas, beliefs, experiences, concerns, interest and feelings toward learners, instruction, and organizations must be understood and inculcated in the structure of such programs (Iqbal et al., 2009; Pardhan, 2003; Perveen and Bhutta, 2012; Saeed and Mahmood, 2002; Shah, 2009). Asghar et al. (2012) mentioned that dynamic interactions between religious, cultural, and scientific spheres of learning come into play, and

due to this, teachers' instructional practices are influenced. Research conducted in Pakistan recognized the contextualized and personalized nature of science teachers' knowledge construction during PD programs (Halai and McNicholl, 2004). Many PD programs served to shift science teachers' knowledge such as changing their perception of science from being a collection of facts to an enquiry-based subject. According to Halai (2011), the most appropriate PD learning experiences for science teachers in knowledge construction were working on enquiry tasks.

Learning needs

The learning needs of Pakistani science teachers are shaped through their command of knowledge and the context in which they work. Those PD programs that are efficient in meeting the distinct learning needs of teachers are the most effective types of programs. The majority of the literature on science teachers' learning and experiences in Pakistan indicated that science teachers' PD courses were highly inflexible and not designed or implemented in ways that are helpful to science teachers (Akhtar et al., 2011). However, effective PD programs that meet teachers' learning needs enabled them to increase high efficacy and strengthen skills to meet instructional challenges (Vazir, 2003). The research likewise found that for any PD program to be effective in Pakistan, it must focus on the needs of the teachers (Akhtar et al., 2011; Chaudary and Imran, 2012).

Reflective practices

The positive features of reflective practices were determined through the perception of improvement activities, equality of treatment, learning culture and effectiveness of school leadership (Alam, 2012; Shamim and Halai, 2006; Westbrook et al., 2009). Halai (2011) found that the knowledge science teachers bring to the classroom could not adequately assist them in teaching and completing their tasks. To be effective, they need a deeper understanding of the content they teach. A science teacher can learn and change his/her practices through continuous efforts

Table 2: A synthesized review of the literature on science teachers' PD learning and experiences in the Pakistani context

Features	Major findings	Researcher(s)
Knowledge and beliefs construction	Science teachers' PD knowledge construction are influenced by their personal knowledge as well as professional experiences	Ali, 2011; Begum, 2012; Halai, 2006; Halai and Khan, 2011; Halai and McNicholl, 2004; Iqbal et al., 2009; Pardhan, 2005; Perveen and Bhutta, 2012; Mahmood, 2013; Shah, 2009; Tahir, 2010; Thomas, 2013
Learning needs	What they already know and what they need to learn are not considered in PD	Akhtar et al., 2011; Chaudary and Imran, 2012; Haider and Ali, 2012; Iqbal and Mahmood, 2000; Vazir, 2003
Teacher research	Teachers learn through their action research opportunities to improve their practices	Halai, 2011; Halai and McNicholl, 2004; Mahmood, 2013; Pardhan, 2005; Penny et al., 2000; Retallick and Mithani, 2003
Reflective practices	Investigation of implemented knowledge should be carried out to identify reflective practices. These reflective practices are influenced by several factors	Alam, 2012; Halai, 2011; Halai and Khan, 2011; Khan and Begum, 2012; Mahmood, 2013; Pardhan, 2003; Shamim and Halai, 2006; Westbrook et al., 2009
Communities of practice	Communities of professional impacted the creation and management of PD knowledge	Ali, 2011; Hashmi, 2011; Shah, 2009; Westbrook et al., 2009
Attitudes for PD learning and experience	Teachers' attitudes can change PD learning and experiences and participation	Aslam, 2013; Halai, 2005; Iqbal and Shayer, 2000; Nadeem et al., 2013; Tahir, 2010

of reflection on his or her learned knowledge (Halai, 2005). Mahmood (2013) found that the improvement of PD practices in Pakistan is significantly dependent on the development of reflective practices.

Teacher research

Studies pertaining to teacher research or action research in Pakistan indicated that science teachers perceived benefits as they become more reflective and made use of what they learned through action-research in improving their teaching and learning practices (Halai, 2011; Halai and Khan, 2011; Mahmood, 2013; Pardhan, 2005; Penny et al., 2000). Halai (2011) found that action research assisted teachers in expanding their knowledge base in three domains of knowledge: Content, pedagogical, and pedagogical CK.

Communities of practice

In Pakistan, the organizational structures such as communities of practice are shaped informally and through social interactions among science teachers. These practices assist science teachers in creating and managing PD knowledge and enhancing their learning abilities. Hashmi's (2011) research on professional learning communities in Pakistan revealed that working in such communities was perceived as a positive experience among science teachers. Positive impact of those activities on student achievement and organizational commitments was also observed (Shah, 2012). Further, research suggested that PD learning and experiences of teachers in Pakistan should focus on promoting group work and activity-based learning initiatives (Westbrook et al., 2009).

Attitudes for PD learning

Science teachers' PD learning is dependent on their positive attitudes and meaningful learning experiences, as well as how they position themselves as learners during PD (Halai, 2005; Nadeem et al., 2013). PD programs in Pakistan are shifting from the non-reflective attitudes to more reflective stance. Iqbal and Shayer (2000) found that a favorable teaching environment with access to proper resources was connected to the motivation of science teachers and their willingness to improve their professional skills. Aslam (2013) concluded that where there was a lack of teachers' involvement in PD planning and training process, there was a lack of interest in and weak attitudes toward PD programs. Similarly, Tahir (2010) observed that those PD activities in which teachers were involved in developing, practicing, and critiquing materials for field experiences were valued more than those that provided ordinary materials. He claimed that success of PD learning depends on the participants' attitudes toward PD and access to experiences in which teachers could actively participate.

Issues Observed in the Effectiveness of PD Programs in Pakistani Context

The research revealed that the nature of most of the PD programs in the public sector was more theoretical than practical and failed to address real-life scenarios of the teaching environment. A key challenge faced by Pakistani science teachers is the lack of relevance of PD programs

to their learning needs (UNESCO, 2015). PD programs are characterized by an inflexible curriculum, which ignores the needs and working conditions of teachers (Akhtar et al., 2011; Aslam, 2013; Haider and Ali, 2012; Iqbal and Mahmood, 2000; Vazir, 2003).

It is a fact that most public-sector schoolteachers have poor subject matter knowledge (Government of Pakistan, 2012). Science teachers' PD programs, in general, consist of several short courses or workshops wherein insufficient pedagogical knowledge is provided to the teachers. Levine (2006) reported that PD learning and experiences were not aligned with their school curriculum, did not include adequate opportunities to practice what was taught, and inferior instruction (Levine, 2006). In addition, literature emphasized the structural and organizational issues in PD learning and experiences, while ignoring the philosophical, conceptual, and pedagogical underpinnings to PD practices (Ali, 2011).

While some PD opportunities helped teachers to reflect critically on aspects of teaching and learning, for example, knowledge, and beliefs about content, pedagogy, and learners, most of the PD practices indicated there were less opportunities for teachers to reflect on those aspects of teaching and learning, thus they remained less productive (Mahmood, 2013; Shah, 2009). Thomas (2013) mentioned that both professionally qualified and professionally unqualified teachers in Pakistan were not significantly different in their beliefs regarding pedagogical CK and utilization of constructivist approaches like student-centered approaches because of their beliefs system. According to Thomas and others (e.g., Hashmi, 2011; Pardhan, 2003), PD opportunities failed to address those pedagogical content issues.

Many studies revealed that contextual and cultural factors appeared to be a hindrance as to changing the instructional practices of teachers. Indeed, contextual and cultural factors weakened teachers' PD learning as a result most of the PD learning and experiences was not transferred to the classroom (Aslam, 2013).

Science teachers in Pakistan stated that it is essential to have social and professional support systems for effective practices (Ali, 2011). However, teachers are unaware of the role of the professional learning community and were found to be reluctant in accepting feedback from their colleagues. Halai (2005) emphasized the need for monitoring teachers' performance and suggested that timely feedback should be provided on their teaching styles and techniques. Most teachers prefer to work in isolation rather than sharing their knowledge among others. Due to the lack of communication between teachers and authorities, they regard themselves as consumers of PD programs rather than contributors (Haider and Ali, 2012; Halai, 2011; Nadeem et al., 2013; Rizvi and Elliott, 2005). To summarize, much of the literature on PD studies in Pakistan laid emphasis on the centrality of science teachers in the PD process. However, there was a strong tendency to overlook the conceptual and pedagogical supporting factors such as active

learning, research, and follow-up strategies. The results and methodologies used were in conformity with the international narrative of PD learning and experiences. The next section examines the research questions in light of the current findings.

DISCUSSION AND CONCLUSIONS

The research questions that guided this literature review were:

1. What is the focus of the literature review on science teachers' PD learning and experiences in the Western context? How do the different features of PD learning and experiences support or impede PD effectiveness?
2. What is the focus of the literature review on science teachers' PD learning and experiences in the Pakistani context? How do the different features of PD learning and experiences support or impede PD effectiveness? and
3. What implications does the information gathered from the literature review have for Pakistani policymakers and researchers for developing research programs in studying PD programs and designing effective PD programs?

This literature review was compiled from 200 peer-reviewed research articles, with more than 75% belonging to the Western context (USA and European countries). The literature review for Pakistan included research articles and a few policy documents on science teachers. This literature was analyzed to understand the comparative features (Tables 1 and 2).

Overall, the literature review highlights the impacts of PD programs on teacher learning and experiences both in Western and Pakistani contexts. Researchers in the Western contexts are more focused on the active involvement of teachers, learning needs, knowledge construction through research and reflective practices, an alignment of PD with standards, PD practices and leadership roles, and so on. (Buczynski and Hansen, 2010; Corte et al., 2013; Lotter et al., 2013; Luneta, 2012; Posnanski, 2010; Saylor and Johnson, 2014; Towndrow et al., 2010).

Whereas in Pakistan, the focus seems to be on teachers' belief, knowledge construction, and PD implementation issues (Begum, 2012; Halai, 2006; Pardhan, 2005). A comparative review of the research findings in both contexts on science teachers' PD learning and experiences are presented in Table 3, the similarities and differences found in both types of literature on the features of PD learning.

The literature both in Pakistani and Western contexts emphasized that the active role of a science teacher, teachers' personal circumstances, and learning needs should be considered while designing and implementing PD activities (Begum, 2012; Borko, 2004; Darling-Hammond and Bransford, 2005; Jita and Mokhele, 2014; Luneta, 2012; Rizvi and Elliot, 2007). However, in countries like Pakistan, PD models such as the "cascade model" or "deficit model" are planned in the formal settings, inadvertently perpetuating the deficits in teacher performance because teachers are not given any autonomy. The disparities between science teachers' needs and governmental priorities for PD learning are not considered.

Hence, science teachers' PD practices are unable to respond to PD implementation requirement effectively. Similarly, PD practices were irrelevant to classroom and school realities. As less focus was placed on the practical work, most science teachers became less motivated and were passive participants within the PD programs.

Another significant similarity of the literature in both Pakistani and Western context is recognizing the complexities of the belief system and knowledge construction as a challenge for effective PD learning and experiences. Recent works in the Western world revealed the complexity of teachers' beliefs systems and the relationship with instructional practices (Fletcher and Luft, 2011; Smith and Lindsay, 2016). However, in Pakistan, like other non-Western countries, construction and internalization of scientific knowledge are different due to science teachers' perceptions about scientific knowledge. Most of them labeled this knowledge as "Western Science" and were resistant to learning in this context which made attitudes even more problematic (Ali, 2011; Aslam, 2013; Halai, 2005). Similarly, Pakistani PD practices were provided through a single workshop, or best a series of sessions that have limited impact in changing their beliefs and knowledge construction, whereas contextual and societal factors omitted from PD have influences on teachers' teaching and learning experiences (Halai, 2011).

Another conformity of Pakistani literature with that of the Western countries' literature was an emphasis on new PD learning pedagogies such as action research, enquiry-based learning, and collaborative or participatory activities. The literature in both contexts recommended an active link between science PD training bodies and the schools where trainees are employed to strengthen and support the PD learning experiences and transform science teachers as reflective practitioners. Emphasis was built on creating common knowledge, common practices, and relevant pedagogies to achieve better PD learning and experience for science teachers. The difference in Pakistani PD practices is that science teachers have no such opportunities available to build their reflective practices, which limits their opportunities to become part of a professional learning community (Ali, 2011; Hashmi, 2011; Pardhan, 2005). A distinctive feature of the literature in the Western context points to the fact that PD learning and experiences had a positive effect on teachers' learning and was supported by features such as school leadership, organizational support, and follow-up activities (Coenders and Terlouw, 2015; Delvaux et al., 2013; Opfer and Pedder, 2011; Rhoton and McLean, 2008). However, the literature in Pakistani context was found to be not focused on this significant feature of leadership. Mostly, teachers thought that the roles of school leadership were ineffective due to lack of guidance, limited resource, and cultural issues embedded in the school context.

In both Pakistani and Western contexts, the literature described the significance of PD learning in changing the attitudes of teachers. However, this attitude change is a complex process

Table 3: A comparative view of research findings on Pakistani science teachers' PD learning and experiences

PD learning features	Pakistani findings like the Western context	Differences/issues in Pakistani context	Implications for Pakistan
Active learning experiences	Researchers emphasize the active participation of science teachers	No differences were observed	Effective PD learning can be achieved through active learning strategies in designing and implementation
Learning needs	Meeting learning needs can impact on teachers' efficacy to meet teaching challenges	PD curriculum is not flexible and relevant to science teachers' needs and ignored their working conditions	PD should be focused, cohesive and aligned with teachers' needs and working conditions.
Beliefs and knowledge constructions	Beliefs and knowledge construction of science teachers must be comprehended and inculcated in PD programs to increase its effectiveness	PD programs ignored the philosophical, conceptual, and pedagogical underpinning of science teacher beliefs and knowledge Teachers' attitudes are less favorable for learning The duration of PD is not enough for knowledge construction nor consistent with the practices	Beliefs change must be evaluated and considered in PD learning and experiences. Changes in Teacher CK and PCK must be assessed as indicators of PD learning
Reflective practices	Reflective practices serve as positive features in learning and improvement of science teachers	Opportunities for reflective for science teachers' practices are less available Reflective practices are only technical in nature	More emphasis should be put on science teachers' opportunities to learn and reflect on their PD practices
Teacher research	Helping in learning of all knowledge domains and in changing practices	Teacher research is a neglected area among science teachers for PD learning and change	An active research culture should be promoted among science teachers to promote flexible learning and change
Communities of practices	It assists in creating and managing PD knowledge for teachers	Teachers are unaware of their role in communities of practices and its significance Most science teachers prefer to work in isolation	Communication between science teachers and authorities must be promoted to build a professional learning community
Leadership and organizational support/ follow-up	No literature was encountered in the Pakistani context		Effective leadership roles are required among science teachers and principals to support PD learning
Participation experiences	PD Learning is dependent on positive and meaningful participation experiences	Traditional models of PD viewed science teachers as deficits of knowledge, hence discouraging their participation	Teacher-centered models of PD learning are needed for effective practices among science teachers
Attitudes towards PD learning	PD learning plays a significant role in changing teachers' attitudes	PD is less supported by policies and resources, and non-involvement in PD activities also impact on their learning	PD must be designed according to improve teachers' attitudes toward learning

CK: Content knowledge, PD: Professional development

and depends on policies and resources. Teachers' approaches to learning appear to be subject to individual experiences within the context of cultural norms (Demir and Ellett, 2014). Teachers in Pakistan need to be motivated to learn through effective practices. Their experiences must be recognized as being relevant and valuable through PD structure, designs, and objectives. Finally, effective PD should include opportunities for teachers to reflect on their pedagogical beliefs and practices.

IMPLICATIONS FOR FUTURE RESEARCH

As highlighted, a significant finding in this comparative literature review is that PD learning and experiences in Pakistan need to be built around the science teachers' needs and practices. Thus, policymakers and developers need to promote

and adopt such learning models that actively involve teachers in the design and implementation of PD programs while addressing each teacher's needs. Similarly, teachers should be provided with incentives to participate in such activities. The beliefs and knowledge construction processes of science teachers in Pakistan should be studied more in-depth.

The comparisons in Table 3 indicate the need for sincere and focused dialogue in Pakistan about on what PD learning and experience depend and what needs to be done to promote the inclusion of cultural norms, reflective practices, and communities of practices. There is a need for effective teacher leaders and school leaders for PD programs in Pakistan, who are flexible, visionary, resourceful in both content and pedagogical CK and able to interact with science teachers.

Leadership should be required and equipped to establish an environment in which science teachers feel empowered and motivated to learn.

A significant finding from the review of the Pakistani literature was that there is a shortage of published empirical research studies on the science teachers' learning and experiences, especially with teachers working in public schools. While building PD research and development culture, stakeholders need to reevaluate existing PD policies and programs in the light of findings in the literature. While the literature in the Western context is useful, further investigations can be done on the effectiveness of PD learning and experiences in Pakistan through understanding the enactment and implementation of PD policies. In the future, PD research in Pakistan should consider the following key questions: Can PD learning and experiences be generalized across the disciplines? How can the development of science as professionals be effective for increasing student achievement? How can stakeholders ensure the effectiveness of PD learning at changing science teachers' beliefs and views about NOS? How can science teachers' PD learning and experiences be differentiated across PD programs in different regions of Pakistan? How can the PD trainers' role influence the learning and experiences of their trainee? What models of PD learning could be suitable for Pakistani context?

The importance of cultural and contextual factors has drawn the attention of researchers around the world (Demir and Ellett, 2014). Future studies in Pakistan could extensively explore the relationship between the science teachers' learning activities, outcomes, and regulation of learning so that an improved system for science teachers' PD learning and experiences could be design and implemented.

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