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Review Article

Professional Learning and Development of Postdoctoral Scholars: A Systematic Review of the Literature

Lorelli Nowell,[1] Glory Ovie,[1] Carol Berenson,[1] Natasha Kenny,[1] and K. Alix Hayden[2]

[1]*Taylor Institute for Teaching and Learning, University of Calgary, 434 Collegiate Boulevard NW, Calgary, AB, Canada, T2N 1N4*
[2]*Libraries and Cultural Resources, University of Calgary, Calgary, Canada*

Correspondence should be addressed to Lorelli Nowell; lnowell@ucalgary.ca

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Increasing numbers of postdoctoral scholars are pursuing diverse career paths that require broad skill sets to ensure success. However, most postdoctoral professional learning and development initiatives are designed for academic careers and rarely include professional skills needed to flourish in nonacademic settings. The purpose of this systematic review was to comprehensively examine and synthesize evidence of professional learning and development pertaining to postdoctoral scholars. The systematic search resulted in 7,571 citations, of which 162 full-text papers were reviewed and 28 studies met our inclusion criteria and were included in this review. This paper synthesizes and classifies studies exploring professional learning and development of postdoctoral scholars. The findings may be used to inform the objectives of professional learning and development initiatives for postdoctoral scholars and contribute to a more rigorous approach to studying professional learning and development.

1. Introduction

Postdoctoral scholars (postdocs) are integral to advancing scientific inquiry and teaching practices in higher education, studying relevant problems, addressing important societal issues, and informing future policy [1, 2]. They hold doctoral degrees and are engaged in mentored research and/or scholarly training for the purpose of developing their scientific independence, academic excellence, and entrepreneurial skills as researchers [3]. Postdoctoral scholars are important members of the research community, who make substantial contributions to research productivity [4, 5], knowledge translation, and collaborative research networks [4].

Traditionally, postdoctoral fellowships have been regarded as short-term positions (1–5 years) intended to bridge the gap between Ph.D. completion and employment in a tenure-track faculty position [1, 2]. However, the growing number of postdoctoral scholars has far outpaced universities' needs for new academic faculty [1, 2, 6, 7], and fewer than 20% of current postdoctoral scholars are likely to obtain tenure-track positions [8]. This trend has resulted in today's postdoctoral scholars commonly following diverse career paths with increasing numbers pursuing opportunities outside of academia in industry, government, and beyond, or leaving research altogether [6].

With the increasing number of postdoctoral scholars pursuing careers outside of academia, these scholars require a broad skill set to fully contribute their intellectual resources and to succeed in their various roles. Interpersonal communication, presentation, leadership, management, networking, and teaching skills [9] are imperative for success in many careers. Yet, with our traditional emphasis on developing scientific knowledge and research skills in postdoctoral roles, few resources are dedicated to the broader professional learning and development of postdocs. Given the considerable personal and societal resources that have contributed to the attainment of this level of educational accomplishment, it is prudent and responsible to ensure that initiatives to help postdoctoral scholars fulfill their potential

and best contribute to society are put into place during their postdoctoral appointments.

As authors, we intentionally use the term "professional learning and development" within the context of our work. This conceptualization ensures a broad focus on the experience and continuous nature of professional learning and professional development, by engaged individuals capable of self-directed learning [10, 11]. Professional learning and development is situated, social, and constructed, and is based on a complex relationship between individuals and their environment [11, 12]. It includes a vast range of informal or formal activities and interactions, as well as contextual learning and reflective action that may increase knowledge, skills, abilities, and growth, and improve performance in present or future roles [11, 13]. These experiences can range from formal structured initiatives (e.g., seminars, workshops, conferences, and courses) to embedded professional and self-directed learning activities (e.g., coteaching, mentorship, group discussions, communities of practice, professional meetings, and reading groups) and to informal everyday discussions and work-related practices with other researchers, educators, and scholars [11, 12, 14].

Postdoctoral scholars have identified a need for adequate opportunities to engage fully in the academic community and to prepare for the various roles and responsibilities of their diverse future positions [3, 15, 16]. However, professional learning and development opportunities for postdoctoral scholars are most frequently designed to support academically focused research careers and are rarely designed to support broader professional skills needed to succeed in nonacademic settings [1, 2, 6]. Although much emphasis has been placed on developing programs for graduate student professional learning and development, far fewer programs exist for postdoctoral scholars [16–19]. There is a distinct paucity of the literature exploring and synthesizing evidence on the professional learning and development of postdoctoral scholars.

1.1. Aim. The aim of this systematic review was to identity and evaluate the nature, strength, and quality of the evidence for professional learning and development of postdoctoral scholars.

2. Methods

2.1. Design. We used an integrated knowledge translation [20] approach for this systematic review with a multidisciplinary team including knowledge users (director of postdoctoral office, postdoctoral scholar, and director of educational development), knowledge synthesis methodologists, an information scientist, and experienced researchers. We followed the Joanna Briggs Institute [21] approach for systematic reviews of both quantitative and qualitative research and the PRISMA [22] and ENTREQ [23] reporting guidelines.

2.2. Search Methods. An experienced librarian (KAH) assisted in designing the search strategy. We aimed for maximum sensitivity to identify all possible eligible literature and further refined our search according to the inclusion and exclusion criteria. We performed and combined several searches to inform the final search strategy. The final search strategy for Ovid MEDLINE is outlined in Table 1 and was adapted to accommodate the indexing systems of the other databases. Comprehensive literature searches were conducted in the following discipline-specific databases from inception until November 16, 2017: Business Source Complete, BIOSIS Previews, CAB Abstracts, CINAHL, Communication Abstracts, Education Resources Complete, EMBASE, Environment Complete, ERIC, IEEE Xplore, MEDLINE, PsycINFO, and SocINDEX. Interdisciplinary databases searched included Academic Search Complete, Scopus, and Web of Science. The grey literature was searched in the ProQuest Dissertations, Theses Global database, Trove (National Library of Australia theses/dissertations), Ethos (British Library theses/dissertations), and websites of national postdoctoral associations (Canadian Association of Postdoctoral Scholars and National Postdoctoral Association). We did not limit the search strategy by study design, or year. The reference lists of all included articles were searched, and Google Scholar "cited by" was used to identify the additional literature. All references were exported to EndNote citation management software, where duplicated records were verified, recorded, and removed.

2.3. Inclusion and Exclusion Criteria. For the purpose of this review, postdoctoral scholars were defined as scholars who hold doctoral degrees and are engaged in mentored research and/or scholarly training for the purpose of skill development [3]. This also included the commonly used term "postdoctoral fellow." We defined professional learning and development as any activities and interactions that may increase postdoctoral scholars' knowledge and skills, contribute to their personal, social, and emotional growth as scholars, and improve their performance in present or future roles. As emphasized previously, these experiences can range from formal structured formats (seminars, workshops, conferences, and courses), to embedded professional development (coteaching, mentorship, group discussions, and communities of practice), to informal discussions with other researchers, educators, and scholars.

Studies were eligible for inclusion if they focused on researching the professional learning and development of postdoctoral scholars. We included qualitative, quantitative, and mixed method studies. The grey literature (theses/dissertations and unpublished studies) was also included to minimize publication and time-lag bias [24]. We excluded books, book reviews, postdoctoral job postings, postdoctoral award notices, postdoctoral funding announcements, interviews with scientists, scientists to watch reports, annual reports, and conference abstracts without full study data.

Table 1: Final search strategy for ovid MEDLINE databases: *ovid MEDLINE(R) epub ahead of print*, *in-process and other nonindexed citations*, *ovid MEDLINE(R) daily*, *and ovid MEDLINE(R)* search strategy.

#	Searches
1	Postdoc*.mp.
2	Postdoc*.mp.
3	Post-phd*.mp.
4	Or/1–3
5	Exp staff development/
6	Exp leadership/
7	Exp mentoring/
8	Exp mentors/
9	Exp teaching/
10	(Professional adj1 development).mp.
11	(Professional adj1 learning).mp.
12	(Professional adj1 growth).mp.
13	(Career adj1 development).mp.
14	(Career adj1 mentor*).mp.
15	(Career adj1 goal*).mp.
16	(Career adj1 preparation).mp.
17	(Career adj1 navigat*).mp.
18	(Capacity adj1 development).mp.
19	(Postdoc* adj2 train*).mp.
20	(Faculty adj1 development).mp.
21	(Collegial adj1 mentor*).mp.
22	(Peer adj1 coach*).mp.
23	Coaching.mp.
24	Mentor*.mp.
25	(Faculty adj3 learning communit*).mp.
26	Work life balance.mp.
27	Lifelong learn*.mp.
28	Transformative learn*.mp.
29	(Talent adj1 management).mp.
30	(Communit* adj1 practice*).mp.
31	Leadership.mp.
32	(Teaching adj1 development).mp.
33	(Teaching adj1 skill*).mp.
34	(Academic adj1 skill*).mp.
35	(Academic adj1 development).mp.
36	(Skill* adj1 development).mp.
37	(Training adj1 program*).mp.
38	(Talent adj1 development).mp.
39	(Skill* adj1 train*).mp.
40	(Education* adj1 development).mp.
41	Or/5–40
42	4 and 41
43	Limit 42 to English language

2.4. Study Selection. Search results were imported into Excel to organize the screening process. Study screening occurred in two phases. During the first phase, two reviewers independently screened titles and abstracts using a structured data entry form. To ensure consistency and reliability and to minimize the risk of bias, data screening forms were pilot tested by reviewers on a random selection of 100 studies. A kappa [25] of 0.85 quantified interreviewer agreement. Variation in screening scores, most frequently related to lack of clarity around identification of postdoctoral participants, was resolved to consensus through discussion. All potentially relevant literatures were passed to the next screening level.

In phase two, two reviewers independently reviewed full-text versions of all potentially relevant literature. Eligibility forms were pilot tested on a random sample of 10 full-text reports to ensure consistency and reliability between the reviewers. A kappa [25] of 0.87 was used to quantify interinvestigator agreement, and disagreements, most frequently related to lack of clarity around study methodology, were resolved by discussion.

2.5. Quality Appraisal. Two authors (LN, GO) independently appraised the quality of all included studies using standardized JBI critical appraisal tools. Quantitative studies were assessed using the JBI Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI), and qualitative studies were assessed using the JBI Qualitative Assessment and Review Instrument (QARI) [26]. Responses to the quality appraisal questions are as follows:

(i) "Yes" (the criteria have been established through the report description or have been confirmed with the primary author)

(ii) "No" (the criteria have not been applied appropriately)

(iii) "Unclear" (the criteria are not clearly identified in the report, and it was not possible to gain clarification from the primary author)

(iv) "Not applicable" (the criteria are not applicable to the study methodology)

Mixed method studies were assessed with both tools. Once the two authors completed their independent assessments, the primary author compared the appraisal scores. As with study selection, all disagreements were resolved through consensus. We did not exclude studies based on their quality; however, study quality was used to interpret and explain differences across studies and incorporated into a narrative synthesis [27].

2.6. Data Extraction. We used a descriptive analytical method to extract contextual information from included studies. The review team developed and piloted a data extraction form, and data from each included article were extracted by one team member and verified by a second reviewer. Data extracted included authors, year, country, publication title, aims and descriptions of professional learning and development, study purpose, study design, context, participants, sample size, theoretical/conceptual framework, definitions of concepts, data collection methods, and relevant results.

2.7. Synthesis. Two authors (LN, GO) conducted the data synthesis. The studies conducted on professional learning and development of postdoctoral scholars varied considerably in aims, study design, and outcomes. Due to the heterogeneous nature of the included quantitative literature, a meta-analysis was not possible; therefore, we used a convergent qualitative synthesis design as described by Pluye

and Hong [28]. All quantitative and mixed method studies were converted into qualitative findings and pooled with the qualitative narrative synthesis using the Bayesian approach described by Crandell et al. [29]. This process allowed for outcomes considered conceptually similar to be mapped into higher-level concepts and themes [30, 31] giving equal weight to both quantitative and qualitative data. A data matrix was created, with concepts and themes in rows and studies in columns, and used to map all data, leaving blank cells when a study did not address a specific theme. Once all data were mapped to the data matrix, an overarching synthesis was created for each theme. Using a data matrix allowed us to explore how quantitative, qualitative, and mixed methods studies furthered and/or challenged current understandings of professional learning and development of postdoctoral scholars, while highlighting current gaps in evidence.

3. Results

Figure 1 illustrates the flow of the literature throughout the review. After comprehensive searching, 7,571 citations were identified, and 28 studies met the inclusion criteria and were included in this systematic review. Table 2 displays the study characteristics, and Table 3 provides an overview of the included studies. Ten studies included postdoctoral scholar samples only, and the others included mixed samples of postdoctoral scholars, graduate students, and or/faculty. Various study designs were utilized including cross-sectional surveys ($n = 15$), mixed methods ($n = 8$), and qualitative designs ($n = 5$). Given the nature of the data presented in qualitative studies where themes were generated from multiple participants (postdoctoral scholars, faculty, and graduate students), only data that were clearly identified as postdoctoral scholar data were included in our analysis.

3.1. Study Quality. Quality appraisal scores for qualitative studies and qualitative components of mixed method studies ranged from low ($n = 7$), medium ($n = 2$), to high ($n = 4$) (Supplementary Table S1). While a number of the qualitative studies described clear objectives and appropriate methods to collect qualitative data, three studies had unclear objectives [34, 51, 54]. The methods of data analysis were often unclear, and there was a lack of thick descriptions of events and circumstances of professional learning and development, reducing our ability to generate an in-depth understanding of professional learning and development of postdocs. However, within the qualitative findings, participant voices were often adequately represented. Only two qualitative studies clearly identified that ethical issues were addressed [42, 52].

Quality assessment scores for quantitative studies and quantitative components of mixed method studies ranged from low ($n = 12$) to medium ($n = 11$), with no high quality quantitative studies identified (Supplementary Table S2). No studies included randomization, most were cross-sectional descriptive surveys, and confounding factors were rarely identified resulting in lower overall quality appraisal scores. Further, many studies used nonvalidated questionnaires, included limited methodological details, making it difficult to appraise validity and reliability of the measures used. The overall generalizability of the quantitative studies was limited. While the quality appraisal scores are reflective of the overall quality of the literature in this field, the quality assessment scores were not used to exclude studies.

3.2. Themes across Studies. In using a data matrix, we were able to visually explore themes between the quantitative, qualitative, and mixed method studies. Six themes emerged in synthesizing the study findings (Figure 2) including teaching and learning skills, writing and publication skills, community development amongst postdoctoral scholars, general career skills, overall work-life balance, and planning for professional learning and development. These themes are presented from most to least prevalent below.

3.3. Teaching and Learning Skills. A number of studies identified postdocs' desires for opportunities to develop skills in teaching and learning [2, 13, 50]. Participants in a multifaceted professional development program identified the greatest impact of participation in professional development activities was on teaching [39]. Authors that studied the outcomes of participating in teaching and learning development identified a number of positive outcomes including increased awareness and interest in different teaching and facilitation practices [32], increased confidence and self-efficacy in implementing active-learning pedagogies [34, 36, 40], increased awareness of the scholarship of teaching and learning (SoTL) [16, 34], and a shift from focusing on teaching to a focus on student learning [34, 40, 41].

A recent study of 17 postdoc cohorts ($n = 177$) found postdocs appreciated the training and mentoring in teaching. One participant was noted.

Nowhere else in my training, have I had any instruction in teaching. The FIRST program had dedicated time for teaching instruction and many opportunities to informally discuss teaching approaches. After completing the FIRST program, I am comfortable and confident discussing and implementing teaching techniques and curriculum changes. The program also introduced me to educational research literature, both as a reader and as a researcher ([42], p. 8).

Others found participating in teaching development enhanced postdocs' abilities to integrate innovative teaching methods into their teaching practice [47]. In the Keen-Rhinehart et al. [47] study, student evaluations indicated postdocs who participated in a teaching development program that developed skills in keeping students engaged, using technology in the classroom, and integrating interactive teaching methods to improve students' understanding and knowledge retention. "Our instructor breaks up the lecture with other activities and makes it much more effective" ([47], p. 78). For postdocs transitioning into academic positions, pedagogical skills and teaching experience were identified as key components to helping them

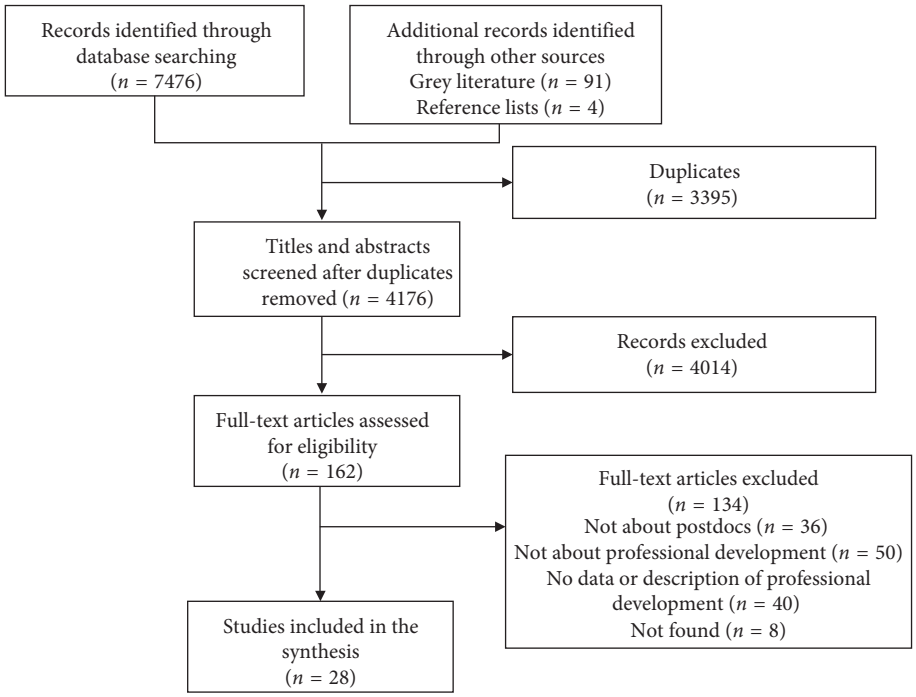

Figure 1: Flow of literature through the review.

Table 2: Characteristics of included studies.

Characteristic		Number	Percent
Country	United States	19	67.8
	Canada	3	10.7
	United Kingdom	3	10.7
	Europe	1	3.6
	Australia	1	3.6
	Africa	1	3.6
Year	2005–2009	7	25
	2010–2014	9	32.1
	2015–2017	12	42.9
Study design	Quantitative	15	53.6
	Mixed methods	8	28.6
	Qualitative	5	17.8
Participants	Postdocs	10	35.7
	Postdocs and faculty	9	32.1
	Postdocs and graduate students	6	21.4
	Postdocs, graduate students, and faculty	2	7.1
	Students of postdocs	1	3.6

prepare for their new academic roles [55]. Further, a study comparing postdocs who engaged in teaching as part of their postdoctoral fellowships compared to those who did not found there were no significant differences in the number of scholars publishing, publication rates, or length of time in postdoc positions [16]. These findings suggest that, when postdoctoral scholars participate in professional learning opportunities to strengthen their teaching practices during their appointments, it does not detract from their research productivity.

3.4. Writing and Publication Skills. Postdocs identified the need for opportunities to develop skills in grant, manuscript, and proposal writing [1, 13, 50] as well as developing presentation skills [2]. Participants in a seminar on scientific writing reported improved writing skills, peer-reviewing skills, and writing productivity [44]. A study about a structured postdoctoral program in the social sciences identified a statistically significant positive effect on postdocs' publication activity [35]. In a recent case study, the overall publication rate of postdocs who had intensive training in both research and teaching exceeded the rate for postdocs focused on research only [42]. Kuhn and Castano [48] reported participation in a mentorship program increased competency in grant writing and science communication.

3.5. Developing a Supportive Peer Network. In 2005, Åkerlind [13] interviewed postdoctoral scholars and identified a common need for the development of supportive networks, as postdoctoral scholars often work in isolation. Postdocs in a professional development program found one of the most useful benefits to be the interactions with their peers [33]. In a recent case study conducted on a postdoc fellowship program, participants identified that they appreciated the power and importance of postdoctoral scholar cohorts and community [42]. One postdoc said the following:

> [A] Major benefit from FIRST was being with a sizable group of other postdocs. We spent a lot of time together discussing teaching, research, the job market, and other aspects of professional development. Several of us traded

Table 3: Overview of studies about professional development and learning for postdocs.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Åkerlind (2005) [13], Australia	To explore postdocs perceptions of the nature of their current positions and concerns about their future career prospects	Qualitative Interviews	22 postdocs and 10 postdoc supervisors	Mathematics, physics, chemistry, Earth sciences, engineering, biological sciences, agriculture, health sciences, social sciences, and humanities	Identified need for (1) opportunities to develop skills in undergraduate teaching, supervision of research students, and grant writing; (2) support to attend skill development courses and academic conferences; and (3) options for those seeking general advice, support, and networking
Ash et al. (2009) [32], USA	To document graduate student and postdoc practices and attitudes regarding teaching in higher education and their perspectives regarding professional development	Ethnography	120 graduate students and postdocs	Science	Increased awareness and interest in different teaching and facilitation practices
Baiduc et al. (2016) [33], USA	To evaluate a professional learning and development program, examine its impact, and modify it based on participant feedback	Pre-post survey	54 graduate students and 22 postdocs over 4 cohorts	Biology, engineering, math, and physical sciences	All program components were highly rated and provided benefits in different respects with no consensus on most valuable aspects. Some found the readings most useful; others benefitted from interactions with the peer community and their faculty mentors
Bauer et al. (2013) [34], USA	Preworkshop survey aimed to explore prior knowledge and experience, academic history, and self-efficacy for teaching and motivation. Postworkshop questions sought beliefs, concerns and plan, and perspective regarding teaching and learning	Mixed methods	Postdocs and graduate students $n = 124$ surveys $n = 9$ interviews	Chemistry	Increased confidence and self-efficacy in implementing active learning pedagogies, increased awareness of SoTL literature, and a shift from focusing on teaching to a focus on learning
Bessudnov et al. (2015) [35], Europe (not countries specified)	To investigate the effects of a large and structured postdoctoral program on academic and nonacademic outcomes	Survey	155 postdocs	Social sciences: economics, social and political science, history, and law	Statistically significant positive effect on the general life satisfaction of former fellows and their publication activity ($p < 0.01$)
Brancaccio-Taras et al. (2016) [36], USA	To assess gains as a result of participating in a Science Teaching Fellows Program, pre- and postactivity knowledge, and actions resulting from participation	Summative evaluation survey	92 graduate students 94 postdocs 48 faculty 1 other	Microbiology	Gains confidence in (1) developing active learning instruction for small classes (82.35%), (2) writing questions that align with learning goals (71.43%), (3) writing learning goals measuring higher-order thinking (74.29%), and (4) talking to others about teaching approaches (70.59%), teaching needs (67.65%), and career goals in science education (64.71%)

Table 3: Continued.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Chang et al. (2008) [37], USA	To assess participant satisfaction and usefulness of specific sessions professional development sessions	Summative evaluation survey	30 postdocs and junior faculty	Not specified	Most participants' "strongly agreed" meeting objectives were valuable and being met and indicated the importance of having a facilitator with expertise
Chen et al. (2015) [38], Canada	To examine activities postdoctoral scholars intentionally engage in to enhance their preparedness for desired careers and factors they perceive as facilitating or constraining their preparation for desired careers	Narrative inquiry	7 postdocs 4 assistant professors	Social sciences and STEM	Participants prepared for desired careers differently depending on available resources including intellectual, networking, and institutional activities. Those with more access to institutional resources (especially a supportive supervisor) and broader networks had smoother postdoctoral phases and positive experiences of preparing for their desired careers
Cox et al. (2011) [39], USA	To explore participant's experiences before, during, and after their affiliations with a research centre's professional development, the impact these experiences had, and how participants implemented their learning during and after their participation	Survey	30 academic consultants, tenure-track faculty, academic staff, and postdocs	Bioengineering Educational Technologies	Respondents differed in their familiarity, application, and operationalization of effective instruction after participation in professional development activities. The greatest impact was on teaching; the least impact was career choices. Respondents who engaged in research while participating used assessment-centered dimension in their work more often than those who did not engage in research (chi-square = 8.611; $p < 0.10$). Respondents who participated the longest are the most frequent users of the knowledge-centered dimension (chi-square = 19.506; $p < 0.10$), the assessment-centered dimension (chi-square = 30.197, $p < 0.01$), and the community-centered dimension (chi-square = 26.871, $p < 0.01$)
Derting et al. (2016) [40], USA	To test the effectiveness of a professional development program for postdoctoral scholars, by conducting a study of program alumni	Survey	Postdoctoral scholars: 19 program participants and 17 nonprogram participants	Biology	Program participants reported using active learning and interactive engagement in lecture sessions more frequently than nonprogram participants. External reviewers documented program participants who taught class sessions that were learner-centered, contrasting with the teacher-centered class sessions of most nonprogram participants. Despite marked differences in teaching practice, all participants used assessments targeting lower-level cognitive skills
Ebert-May et al. (2015) [41], USA	To determine the extent to which postdocs believed in and implemented evidence-based pedagogies after completing a 2-yr professional development program	Mixed methods	190 postdocs	Biology	Greater use of learner-centered compared with teacher-centered strategies. Despite practice of higher-level cognition in class sessions, assessments of learning focused on lower-level cognitive skills

Table 3: Continued.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Eisen and Eaton (2017) [42], USA	To explore if postdocs who have intensive training in both research and teaching, perform well or better than traditional research-only fellows in publishing, obtaining, and remaining in research-related employment, and earning research grant support once employed and if success in these areas may in part be due to the community that emerges as a result of explicit and structured training in teaching and research together	Mixed methods: case study	177 postdocs	Science	Publication rate of postdocs who have intensive training in both research and teaching that exceeds the rate for both comparison groups ($p = 0.027$ for Emory T32 fellows, $p = 0.0052$ for T32 fellows from other institutions). Fellows appreciated the cohorts and community and training and mentoring in teaching, especially in conjunction with training in research. Other emergent themes included the opportunity to have an excellent research experience, to teach and network, the chance to obtain leadership and administrative experiences, having independent funding, and gaining confidence and focus in general as a scholar
Gerdeman et al. (2007) [43], USA	To evaluate the impact of career development workshops and seminars	Survey	24 faculty 8 postdocs	Chemistry	The three most highly rated seminar components were developing a teaching philosophy; learning about the system of higher education; and discussing learning theory
Gianaros (2006) [44], USA	To evaluate a problem-based learning seminar on scientific writing for psychology graduate students, postdoctoral trainees, and junior faculty	Survey	3 graduate students 5 postdocs	Psychology	Participants reported improved writing skills (M = 3.70; SD = 0.61), peer-reviewing skills, and writing productivity
Hobin et al. (2014) [45], USA	To examine awareness, use, benefits of creating an individual development plan (IDP), and ways to facilitate its use	survey	57 postdoc administrators 267 postdocs	Not specified	Most postdoctoral administrators (>80%) were familiar with IDPs, less than 50% of postdocs and only 20% of mentors were aware of IDPs. Creating an IDP helped postdocs identify skills and abilities necessary for career success and facilitated communication between postdocs and their mentors
Holtzclaw et al. (2005) [46], USA	To analyze the postdocs preparedness for future faculty positions	Mixed methods: survey and interviews	47 postdocs, half of whom are minorities and three quarters are women	Science	Teaching skills increased from slightly to greatly. Unexpected benefits include increased postdoc community, increased participation by minorities, and increased research and teaching collaborations between the two institutes
Jadavji et al. (2016) [1], Canada	To identify postdocs perspectives regarding supports and obstacles to desired outcomes of their postdoctoral position	Survey	2109 postdocs	Interdisciplinary, social sciences, physical sciences, and life sciences	The majority of postdocs do not participate in external training activities. Training that would be of interest to international postdocs included English-language training and writing skills. Project management, grant writing, and career development remain the top areas of interest for more than 40% of postdocs

Table 3: Continued.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Keen-Rhinehart et al. (2009) [47], USA	To investigate the effects of interactive teaching methods learned through professional development programs, by testing two interactive teaching methodologies to determine if they would improve learning and retention when compared with standard lectures	Mixed methods: test and student comments	65 students of postdoc fellows	Neuroscience	Teaching training-enhanced postdocs ability to integrate innovative teaching methods into their instruction. Data from student evaluations demonstrated postdocs have exceptional teaching skills, especially in keeping students engaged, using of technology and overall effectiveness. Interactive teaching methods improved student's ability to understand and retain class material
Kuhn and Castano (2016) [48], USA	To examine participant expectations of the program and their subjective baseline skills and measure improvement at the end of the program	Pre-post survey	70 postdoc mentors were senior postdocs in the last years of their postdoctoral training and mentees were junior postdocs in their first two years of postdoctoral training	Science	Self-assessment revealed significant improvement in knowledge and skills including competency in development of career skills, exploring nontraditional careers, learning how to transition to industry, academic problem resolution, networking, interviewing skills, CV preparation, grant writing, science communication, and improvement of work-life balance. Mentors strongly agreed the program met their expectations and highly recommend it. One year after the program, 46.6% of mentees were promoted to instructors/junior faculty (20%), college professors (6.6%), or staff researchers (6.6%) and 13.3% moved to industry scientist positions
Lee et al. (2010) [49], UK	To determine the experiences, opportunities, and challenges of postdoctoral researchers in relation to academic achievements, research environments, previous experiences, future career motivations, and skill development	Survey	46 postdocs	Medicine	Postdocs rated eight competencies as significantly more skilled compared to the mean including research skills and techniques, personal effectiveness, teams/networking, recognising and validating problems, and demonstrating original independent research, critical skills, analysis, and knowledge of recent advances in their field. Skills that fell below average related to career development, communication, and awareness of research environment, which were associated with higher publication rates and improved by career mobility, suggesting those skills, are key to the development of researchers and their employability

Table 3: Continued.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Matyas et al. (2011) [50], USA	To identify topics and issues important to graduate students, postdoctoral fellows, and new investigators in physiology	Surveys	362 graduate students, 276 postdocs, and 111 new investigators	Physiology	Identified needs closely related to specific career stages with mentoring, teaching, and managing a laboratory and authorship polices were highly rated topics of interest. More professional activities were desired for writing grants and manuscripts, funding and award opportunities, attending and presenting at meetings, learning about awards and travel funding, reviewing manuscripts, career options available, job searching and interviewing, advancement and promotion, negotiation skills, international issues, and balancing family and career
McAlpine et al. (2017) [51], UK	To assess and document postdocs perceived challenges to achieving PI-ship, where they wanted help and forms of support that would be beneficial	Qualitative interviews	60 postdocs across disciplines in three universities	Not specified	Future development activities should incorporate positive coping strategies in developing resilience. Personal lives (e. g., partner and childcare) influence work choices. Many new PIs felt ill prepared for their responsibilities including growing a research group, managing and enabling others, and dealing with personnel/human resource issues
McCullough (2010) [52], Africa (countries not specified)	To evaluate the use of personal development planning (PDP) as a strategy to enhance, plan, and manage career development	Mixed methods: surveys and interviews	10 PhD students and 14 postdocs	Not specified	PDP positively enhanced and progressed career development and increased confidence in planning and managing career development and progression
Mitchell et al. (2013) [2], Canada	To present demographic data about Canadian postdocs and to identify their primary concerns	Survey	1830 postdocs	Not specified	Postdoctoral training rarely includes the professional skills needed to succeed in nonacademic settings. Postdocs are interested in grant writing and proposal writing (67.3%), research ethics (7.9%), French language skills (12.6%), English-language skills (14%), conflict resolution skills (16.2%), presentation skills (16.6%), intellectual property (20.1%), writing skills (25.6%), negotiating skills (28.4%), group or lab management (37%), teaching skills (40.9%), career development (47.3%), and project management (48.4%)
Phillips (2010) [53], UK	To understand postgraduate students and postdocs views about enterprise skills training and identify their future needs	Qualitative: focus groups	4 postgraduates and 4 postdocs	Not specified	Half of participants attended seminars on presentation skills and/or time management with varying usefulness. Reasons for not completing training included timing, lack of supervisor support, lack of awareness of existing training, and lack of time. Topic suggestions for future training included sales and marketing, management, handling rejection, explaining science to nonscientists, and risk and uncertainty management

Table 3: Continued.

Author/year country	Study aims	Study design	Participants	Research fields	Results
Reid Ponte (2015) [54], USA	To rate and comment on professional development program components and identify what helped and/or impeded goal achievement, aspects of the program that would benefit from change, and whether they would recommend the program to a colleague	Mixed methods: survey and interviews	4 postdocs, 3 nurse mentors, and 4 interdisciplinary mentors	Nursing	The number of courses taken by the fellows ranged between 0 and 5, and those who took courses generally found them very useful. There was some dissatisfaction with the amount of information given about available educational resources. Mentors described a positive experience when a good working relationship was established, and the mentee was productive. Mentors described a less positive relationship when the mentee was unhappy or not very productive or asking for frequent interaction. None of the mentors described the time requirement as burdensome
Rybarczyk et al. (2016) [55], USA	To examine factors that promote the transition of postdocs into academic careers in STEM	Mixed methods: productivity metrics and interviews	77 postdocs (80% female and 10% underrepresented minorities) and 10 of whom were interviewed	STEM	Postdocs intended career outcome, not demographics or the type undergraduate institution attended, predicts the actual career outcome attained. The total number of publications (OR: 2.75; 95% CI: 0.97–7.80; $p = 0.058$), four or more first-author publications (OR: 3.57; 95% CI: 1.12–11.35; $p = 0.031$), and discipline area (OR: 5.27; 95% CI: 1.11–24.87; $p < 0.05$) were positive and significant predictors of actual career outcomes. Number of courses taught and students mentored were positive variables but not significant predictors of career outcomes. Scholars who attained tenure-track faculty positions had a greater number of publications (mean = 7.5; median = 6) compared with scholars who transitioned into nontenure-track or nonacademic positions (mean = 5.6; median = 5). All 10 alumni felt prepared for their new positions, at ease with teaching and transitioning into their new faculty roles. Pedagogical skills and teaching experience were key components of preparation
Rybarczyk et al. (2011) [16], USA	To identify if formal postdoctoral training programs, that include additional training in teaching, increase the probability of obtaining an academic position and if the program provides measurable, positive impact on undergraduate education	Survey	Over 700 postdocs	STEM	No significant differences in number of scholars publishing, publication rates, or length of time in postdoc positions, between the comparison group and those who attended additional training in teaching. Increased interest in the scholarship of teaching and learning resulted in broader impacts on undergraduate education including changes in course structure, engagement of students in research-based courses, inquiry-based teaching, introducing technology in the classroom, and the development and assessment of learning tools such as case studies

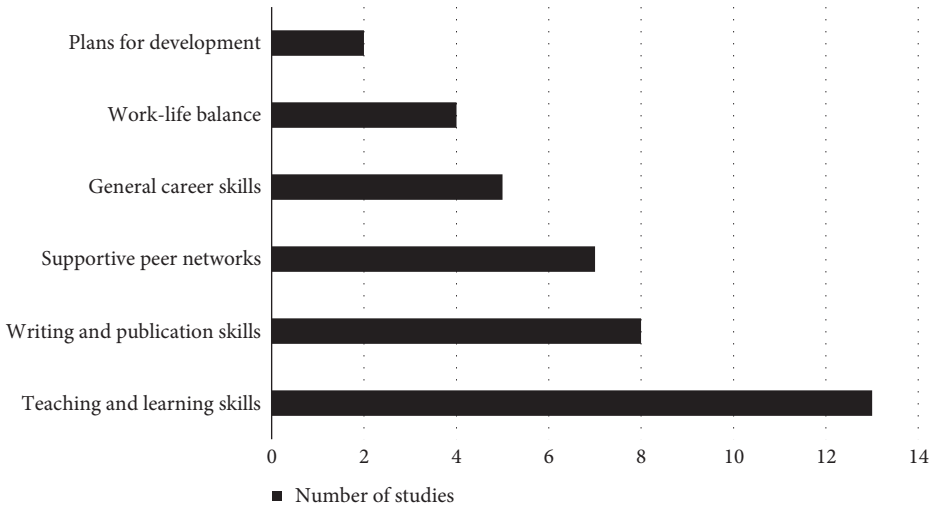

Figure 2: Prevalence of themes identified in the literature.

> documents during our first wave of applying for professorships... These have been some of the most important career relationships that I have developed ([42]; p. 7).

Others studies identified developing peer networks and social interaction to be one of the unexpected benefits of engagement in professional learning and development opportunities for postdocs [46]. Those who engaged in developing a peer network during their postdoctoral fellowship had smoother postdoctoral phases and positive experiences of preparing for their desired careers [38]. Further, postdocs who participated in professional development also gained skills and competencies in developing teams and peer networking [48, 49].

3.6. General Careers Skills. Postdocs wanted to learn about a number of career-related topics including career options, job searching, interviewing, advancement and promotion [50], negotiation and project management skills [2], as well as handling rejection, explaining science to nonscientists, and risk and uncertainty management [53]. Participants who attended professional development seminars identified a number of career benefits including exposure to academic job options, improved preparation of job searching, and exposure to knowledge valuable for the reality of faculty work [43]. Kuhn and Castano [48] examined self-assessment of skill development through a pre-post survey of postdocs who participated in a mentorship program. Achievements attributable to participation in the program included successful job interviews, as well as opportunities to explore nontraditional careers, to learn how to transition to industry, and to strengthen their interviewing skills [48].

3.7. Work-Life Balance. McAlpine et al. [51] recently conducted a need assessment of postdoctoral scholars and identified the need for professional learning activities focused on positive coping strategies in developing resilience and exploring how personal lives (e.g., partner and childcare) can influence work choices. Similarly, Matyas et al. [50] found participants wanted to learn more about balancing family and career. A study exploring academic and nonacademic outcomes of participating in a structured postdoctoral professional development program found the program had a statistically significant positive effect on the general life satisfaction of participants [35]. Postdoctoral scholars in a formalized mentorship program identified their work-life balance has improved as a result of participating in the program [48].

3.8. Planning for Professional Learning and Development. Two studies explicitly explored individualized professional development planning [45, 52]. Hobin et al. [45] found that, although most postdoctoral administrators (>80%) were familiar with individual development plans, fewer than 50% of postdocs and only 20% of postdoctoral supervisors were aware of individual development plans of how to use them. Postdocs who created individual development plans found that the plans helped to identify the skills and abilities necessary for career success and facilitated communication with their supervisors [45]. McCullough [52] evaluated the use of personal development planning as a strategy to enhance and progress career development amongst postdocs based in eight developing countries in Africa. The findings from this study suggested professional development plans (PDP) increased confidence in planning and managing career development and progression [52]. One participant indicated the professional development planning helped to focus on areas that needed further development but also "allowed me to explore areas I may not have ventured into if it were not for writing out my PDP" ([52], p. 143). Another participant highlighted that professional development planning "helped me to think thoroughly about myself and strengthened my conviction in my career planning and development" and that "it made me reflect on what I actually wanted to do with my professional life" ([52], p. 142).

4. Discussion

This systematic review was conducted to examine and critically appraise the current state of evidence of professional learning and development of postdoctoral scholars. Detailed examination of 28 included studies revealed that professional learning and development had a positive impact on postdocs' teaching and learning skills, writing and publication skills, and general career skills. Other outcomes of engaging in professional learning and development included developing a community of peers with other postdocs, enhancing work-life balance, and purposefully planning for professional learning and development. However, it is important to view these findings with caution as many of the included studies were of medium to poor quality which prevents us from drawing strong conclusions about the professional learning and development outcomes for postdoctoral scholars.

Our findings are similar to research related to graduate student professional learning and development. In a study examining graduate students' experiences of professional development programs, Rizzolo et al. [56] found that participants valued opportunities which supported their job readiness as it pertained to academia and their field of study (e.g., resume preparation, job search, and interviewing skills). Participants also highlighted the importance of programs that helped foster networking, the development of positive relationships, and a sense of community with their peers. They also found that many graduate students desired professional development opportunities that promoted balance in all aspects of their life, especially in strengthening their ability to meet both their personal and professional commitments. Rizzolo et al.'s [56] and our findings related to developing skills in work-life balance and personal coping align with literature calling for a greater emphasis on workplace well-being throughout the academic community [57, 58]. Given the dearth of research related to how best to support the well-being of postdoctoral scholars in academe, there is need for future research in this area.

In terms of the topics of focus for professional development programs, graduate student programs typically center around on two areas: (1) academic skill development (e.g., research and teaching) and (2) transferable workplace skills (e.g., leadership, communication, project management, and career planning/searching) [18]. As universities emphasize the quality of undergraduate education, research has also confirmed the importance and pedagogical benefits of graduate student teaching development programs [59–65]. What most differentiates graduate student and postdoctoral scholar professional development is that graduate student professional development programs tend to place a much stronger emphasis on transferable workplace skills outside of the context of academe. As highlighted in the above findings, postdoctoral scholar programs focus most clearly on the development of academic research and teaching skills that will best prepare postdocs for traditional tenure-track faculty positions.

The research on professional learning for academic staff largely focuses on teaching and learning, and there is considerable research aimed at discerning the short- and long-term impacts of teaching development programs on individual instructors, student learning, and institutions. In the literature, teaching expertise is understood as developmental [66, 67] and broadly complex [68]. The various facets of teaching expertise, which can be aligned with some of the themes from the postdoc literature, include teaching and supporting learning; educational leadership; mentorship; research, scholarship, and inquiry; and professional learning and development [68]. As with the findings from the postdoc literature, it is acknowledged that intentionally designed, sustained teaching development programs help academic staff adopt student-centered approaches to teaching that strengthen educational quality and improve student learning outcomes and experiences [69]. The skills learned in instructor certificate programs are seen as important for faculty at all career stages, given the increased use of technology to support teaching and the learning habits of incoming students in the current postsecondary environment [70].

Despite some of the limitations of the evidence for professional learning and development for postdoctoral scholars, a number of suggestions can be made when compared to the evidence for professional learning and development of graduate students and academic staff. Given that professional learning and development can have a positive impact for postdocs on the development of teaching and learning skills, writing and publication skills, and general career skills, institutions should encourage and support professional learning and development in these areas. These findings align with Rose [18] who clearly recommends that institutions prioritize and dedicate appropriate resources to graduate student professional development that broadly support their academic and career success. We concur that the same recommendation should be made for postdoctoral scholars. Knowing that postdocs often experience feelings of isolation [51], having opportunities to come together to participate in professional learning and development may help postdocs to develop a positive sense of community and decrease their feelings of isolation. Postdocs aim to advance their research profiles, often with minimal guidance or clarity [71, 72], and professional learning and development may help postdocs purposefully plan individualized learning and development goals. With the vast majority of postdoctoral scholars seeking careers outside of traditional university settings, it seems prudent for academic institutions to place increased focus on professional learning opportunities that encourage the development of career skills (e.g., leadership, communication, project management, and interpersonal skills) that will best support their future careers in a broad range of settings.

Although a robust and systematic method was used to identify all published literature focused on professional learning and development of postdoctoral scholars, we cannot rule out the possibility that our search missed some relevant sources. Contacting experts in postdoctoral scholars' professional learning and development may have helped identify more grey literature to include in our review.

A majority of articles were from the United States, Canada, and the United Kingdom reflecting the current state of evidence of professional learning and development of postdoctoral scholars; however, the unbalanced geographical picture may not accurately reflect professional learning and development opportunities in other countries. Despite these limitations, the findings from this systematic review reflect the current state of evidence for professional learning and development of postdoctoral scholars. The findings may be used to inform the objectives of professional learning and development initiatives for postdoctoral scholars and contribute to a more rigorous approach to supporting and studying professional learning and development.

Although a number of studies have examined the benefits of professional learning and development for postdocs, there are few comparative research designs and no longitudinal or multisite studies. However, this systematic review suggests that teaching and learning skills, writing skills, and general professional skills are important opportunities to include in professional learning and development opportunities for postdocs. The impact of the design and delivery of individual professional learning and development programs remains an underexplored area of research. Additional comparative studies are needed to identify effective approaches to design, embed, and promote professional learning and development as part of postdoctoral fellowships.

5. Conclusion

Engaging in professional learning and development can enhance postdocs' teaching and learning, writing, and general professional skills while furthering their socialization and balancing of work-life responsibilities. This review provides an initial step to help advance professional learning and development opportunities for postdocs. While there are clear benefits to engaging in professional learning and development, future research is needed to determine how institutions can assure postdocs have equitable and ongoing access to professional learning and development opportunities.

Disclosure

This manuscript was presented at the Society for Teaching and Learning in Higher Education 2018 Conference.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Supplementary Materials

Table S1: quality appraisal scores for included qualitative studies. Table S2: quality appraisal scores for included quantitative studies. (*Supplementary Materials*)

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