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A Synthesis of the Research on Community Service Learning in Preservice Science Teacher Education

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Despite recent recommendations urging stronger connections between teacher education programs and their communities, few studies have examined the potential of community service learning (CSL) within science teacher education. The paper aims to: understand how CSL is conceptualized in preservice science teacher education contexts; identify the various ways that CSL is integrated within courses; examine stated outcomes for preservice science teachers, and; explore how research on CSL has been carried out in science teacher education. To better inform science teacher education, the authors embarked upon a research synthesis of relevant articles within preservice science teacher education. Six main findings emerged from the synthesis: (1) different science teacher education programs define CSL similarly, (2) preservice science teachers' engagement with CSL is primarily reported as being beneficial, (3) mixed outcomes are reported in preservice teachers' self-efficacy, confidence, and attitudes toward teaching science, (4) challenges, if reported, tend to be from the perspective of preservice teachers, (5) several common teaching strategies are employed to support the CSL experience, and (6) case study is the most typical research methodology for studying CSL, where the researchers are the instructors of their own CSL courses. These findings are significant for the ongoing development of science teacher knowledge and programmatic directions for the integration of community in science teacher education.

Keywords: community service learning, community engagement, teacher education, science education, teacher education strategies

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INTRODUCTION

This study offers a qualitative synthesis of the research on community service learning (hereinafter referred to as CSL) within preservice science teacher education programs (Minner et al., 2010). In this background section, the authors describe briefly the history of CSL in university and teacher education in general and its entry into preservice science teacher education. Given the list of potential benefits within teacher education literature and for schools, science teacher educators have adopted CSL within teacher education programs. The authors' primary research aims are to inform science teacher education by: addressing how CSL is conceptualized in preservice science teacher education contexts, identifying the various ways that CSL is integrated within courses, examining stated outcomes for preservice science teachers, and exploring how research

on CSL has been carried out in science teacher education. This synthesis on CSL is significant because of the increased attention being paid to promoting more CSL in teacher education (Hildenbrand and Schultz, 2015; Guillen and Zeichner, 2018) and because positive changes to preservice science teacher's education can have a concomitantly high impact on their students' achievement (Darling-Hammond and Post, 2000; Darling-Hammond and Snyder, 2000; Darling-Hammond, 2006). Despite the attention, CSL remains a relatively less explored area of research in science teacher education. Science teacher education in particular is searching for ways to foster STEM teaching and learning. The findings of this research synthesis could point to possible directions for future research on CSL, preservice science teacher education and STEM education.

Of note to this special issue are findings related to preservice science teachers attempting to further their intercultural sensitivities and teaching competencies. Several articles in the synthesis noted a deficit model of the communities they served in preservice science teachers' beliefs about under-socialization, poor language practices, disinterested parents, and under-achievement (Bryan and Atwater, 2002; Comber and Kamler, 2004; Gonzalez et al., 2005). Moreover, teachers themselves have concerns that they may merely extract curricular and other local knowledge from the community for their benefit (Handa et al., 2008; Handa and Tippins, 2012) and without reciprocation. CSL experiences for preservice science teachers are not without risks in amplifying the deficit model (Tilley-Lubbs, 2011) but they appear to hold potential for advancing sensitivity, equity, and diversity in the classroom (Baldwin et al., 2007).

BACKGROUND ON CSL

Field experiences, such as observing the work of educators in school classrooms (LaMaster, 2001), are a vital component of teacher education programs as they have been historically viewed as critical bridges between formal teacher education programs and teaching practice (Beeth and Adadan, 2006; Zeichner, 2010, 2011). Specifically, since preservice teachers begin teacher education programs with strong, and sometimes erroneous, beliefs about teaching and learning that they gained by being students for many years (Darling-Hammond, 2006), field experiences have been conceptualized as necessary components of the development and validation of knowledge about teaching (Coffey, 2010). International analyses of trends in the teaching profession report that field experiences are being offered more frequently in teacher education programs and in increasingly varied formats (LaMaster, 2001; Organization for Economic Co-operation Development (OECD), 2005a,b; Purdy and Gibson, 2008; Kennedy and Archambault, 2012; Hamilton and Margot, 2019).

CSL has gained further momentum as a particular approach to the field experience component of professional programs since the 1990s (Bringle and Hatcher, 1996). CSL has been defined as:

> A course-based, credit-bearing educational experience in which students (a) participate in an organized service activity that meets identified community needs, and (b) reflect on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of personal values and civic responsibility (Bringle and Hatcher, 2009, p. 38).

As Celio et al. (2011) and Bringle et al. suggest 2012, CSL is an activity that, for higher education, has been associated with further understanding of a discipline. The mechanism for this to occur is scholarly engagement (Boyer, 1997; Bringle and Hatcher, 2000) that, "[L]ink[s] theory and practice, cognitive and affective learning, and colleges with communities" (Butin, 2006, p. 473).

Learning in CSL has also been described as considering the community as a real-world laboratory to test concepts from the discipline (Erickson and Anderson, 1997). When learning occurs in community service, it has been further characterized as a process of transfer from situation to situation, the building of experiences on a continuum, or the problematization of the experience that sponsors further inquiry (Giles and Eyler, 1994).

Campus-wide offerings of CSL in the US have been spurred on with the support of National Community Service Trust Act of 1993 and national organizations and coalitions, such as: Campus Compact, the National Society for Experiential Education, and the National Service-Learning Clearinghouse (NSLC) (http://www.servicelearning.org)[1] (Bringle and Hatcher, 1996). The mobilization of higher education to begin to also offer campus-wide CSL has been in response to, "[G]rowing social and environmental problems in many US communities and with substantial financial support from the US government's Corporation for National Service" (Wade et al., 1999, p. 667). In 2000, university guidelines and rubrics for supporting faculty and community partnerships were being written, signaling the further institutionalization of service learning within higher education (Furco, 2002; Boyle-Baise and McIntyre, 2008). The University of Pennsylvania was among one of the US universities that aimed to build strong connections with communities, by strengthening its partnerships in West Philadelphia and facilitating service learning initiatives among various disciplines (Harkavy and Hartley, 2010). This and other campus initiatives suggest that by 2010, CSL was an instantiated pedagogy for community engagement and learning.

PRESERVICE TEACHER EDUCATION AND CSL

The use of CSL in teacher education has been historically cast as an elective, yet more recently, schools and faculties of education are offering CSL as required component of teacher education (Jagla and Tice, 2019). To distinguish it from a form of charity work with children, efforts are made to conceptualize CSL as, "Learn[ing] and develop[ing] through active participation in thoughtfully organized service experiences that meet actual community needs" (Buchanan et al., 2002, p. 30), and, "[B]lend service activities with the academic curriculum in order to

[1] *National* Service-Learning Clearinghouse. Available online at: www.servicelearning.org (accessed September 01, 2018).

address real community needs while students learn through active engagement" (Anderson and Pickeral, 1998).

Reported purposes for CSL in teacher education are to provide meaningful experiences that support course goals, including: testing educational concepts, theories and practices, preparing for practicum (Coffey and Lavery, 2015), improving children's learning, fostering community engagement (Klehr, 2015; Pitre et al., 2017), and developing awareness, reciprocity and humility in relation to the wider society in which they work and inhabit (Billig, 2000; Swick and Rowls, 2000; Verducci and Pope, 2001; Covitt, 2002; Lund and Lianne, 2015; Barnes, 2017).

CSL in preservice teacher education is often compared with the practicum. According to the literature, CSL is often measured in terms of, "[T]he quality of the service and learning outcomes" (Cone, 2009b, p. 369) between the service provider (i.e., preservice teacher) and the recipient (i.e., community). CSL distinguishes itself from the practicum in terms of these indicators and its aims to present mutual benefits to its partners or stakeholders (i.e., teacher educators, preservice teachers, community groups, parents, and the children they serve) (Furco, 2003; Karayan and Gathercoal, 2005). As we, "[P]repare future educators to better understand and empathize with the needs of the communities in which they will be working" (Coffey, 2010, p. 336), Anderson and Hill (2001) offer that, "[R]eciprocity and mutual respect should characterize [this] collaboration among teacher education programs, p-12 schools, and the community" (p. 76). Donahue et al. (2003), define reciprocity as positioning both the provider of service and the recipient, children or schools, as learners. CSL emphasizes learning from experience, deliberate reflection, group discussions, and class projects (Cone, 2009a; Coffey, 2010). CSL experiences in preservice teacher education are cited as: contributing to the long-term enhancement of the community (Swick, 2001), deepening future teachers' understanding of diversity and the 'other' (Swick and Rowls, 2000; Cooper, 2007; Chang et al., 2011)), developing an understanding of values consonant with education (Swick and Rowls, 2000), increasing awareness, sensitivity and familiarization of social realities within the society (i.e., social gaps, poverty, unemployment) (Yogev and Michaeli, 2011), addressing culture and race among teacher candidates who have little to no experience working in diverse communities (Baldwin et al., 2007; Kim, 2012), forming more complex notions of learners and ways of meaning-making (Ryan and Healy, 2009), and gaining special insights into students' lives outside of formal educational settings (Coffey, 2010).

A RESEARCH SYNTHESIS ON CSL IN PRESERVICE SCIENCE TEACHER EDUCATION

Research syntheses are used in educational research to demonstrate important interactions among relevant issues and factors from an analysis of existing literature and then to draw conclusions and build theories for further research (Minner et al., 2010). Qualitative research syntheses can be defined as, "[S]ystematic efforts of synthesizing qualitative research" (Suri and Clarke, 2009, p. 401). Within the educational research field, synthesis research has taken the route of, "[S]ynthesizing methodologically diverse research and synthesizing research from critical perspectives" (Suri and Clarke, 2009, p. 401). A main interest in undertaking a qualitative research synthesis for this study was to establish a method for reviewing diverse contributions- many of which were qualitative in nature[2]. Related to this point, research syntheses can involve reviews of literature from a small data set (cf. Nine articles, Major, 2010) to a larger dataset (cf. over 50 articles, Sadler, 2009).

The authors' research synthesis follows Minner's et al. (2010) three-phase approach that involves: (1) search and inclusion, (2) individual study review, and (3) a cross-case comparison and analysis. Phase 1 of the synthesis involved a search of the ERIC database using the EBSCOHost interface. The keywords "service learning" and "preservice" and "science" were searched among articles published between 1999 and 2018. Additionally, the same search terms were also employed within the Google Scholar search engine and the following primary research journals: American Educational Research Journal, Journal of Research in Science Teaching, yielding 46 results. References in each of the identified articles were subsequently checked for related articles. The results identified 22 new articles from the Journal of Science Teacher Education, International Journal of Science Education, Journal of Science Education and Technology, Journal of Teacher Education, Science Education, Teaching and Teacher Education. Thus, a total of 68 articles were analyzed.

In the search and inclusion phase, we followed the methodological considerations for research syntheses, as outlined by Suri and Clarke (2009). These authors suggest the following three principles: "[I]nformed subjectivity and reflexivity, purposefully informed selective inclusivity, and audience-appropriate transparency" (p. 408). It is worth expanding on these three guiding principles of informed reflexivity, inclusivity, and transparency for a quality research synthesis.

Regarding subjectivity and reflexivity, Suri and Clarke (2009) suggest synthesists reveal their motivations for conducting the review and their personal standpoints as researchers so as to better contextualize their interpretations of the findings. The two motivations driving the authors' research here illustrate Suri and Clarke's point. First, the authors' own experience with this approach in a specialized course for preservice science teachers hinted at the value of CSL, thus motivating an analysis of its use as a pedagogy for teacher education (Falkenberg, 2010; Zeichner, 2011). Second, the authors also hoped to employ the research synthesis to reflect upon CSL as pedagogy for pre- service teachers in out-of-school programs for learning science (Feldman and Pirog, 2011; Bevan et al., 2013).

According to Suri's second principle, "All decisions in a research synthesis must be guided by the principle of purposefully informed selective inclusivity" (2009; p. 412). In this synthesis, the sampling criteria was purposefully informed by

[2]The excluded articles lack transparency and drew conclusions that are different from those included. The diversity of methodologies appears to often reflect research undertaken by academics who were also the instructors of the CSL courses they were studying.

the desire to speak to the possible needs of preservice science teachers, science teacher educators, and, community organizers that are aligned with some of the goals of science teacher education programs. The initial list of 68 articles from phase 1 was vetted by the following inclusion and exclusion criteria. The articles must: (1) include research on K-12 preservice teacher education (both elementary and secondary) (2) be relevant to the teaching of science, (3) integrate CSL as a component of a pre-service science teaching course, and (4) represent empirical studies published in journals rather than technical reports or proceedings.

Finally, and following Suri and Clarke third principle (2009, p. 413), this research synthesis focused on the, "[T]ransparency of process to enhance accountability, credibility, and transferability of synthesis findings." The "transparency of process" criteria significantly decreased the number of articles. Despite their ability to broaden the focus of this review, articles that lacked clear descriptions of their research methodologies were excluded. As a result of the guiding principles posited, articles such as Chinn (2006) and Pappamihiel (2007) were excluded, leaving a total of 25 key articles.

Phase 2 involved the analysis of the remaining 25 articles. Specifically, the articles were examined and summarized with notations in a research synthesis table that includes the categories of the focus of the study, the CSL course and context, and outcomes in terms of science teacher knowledge and practice, community, and children. Notations related to methodology, such as the study's data sources and participants were included in the analytic table to foster methodological comparisons among the studies. A review team met with the authors of this paper to review the salient aspects of the various articles and to assist in reaching consensus on the inclusion of articles in any one of these categories.

Phase 3 of the research included a comparison (and contrast) of the final 25 studies within the categories identified within Phase 2. Analyses were expanded, "[T]o consider themes, shapes, and organization of research ideas present in the overall literature" (Opfer and Pedder, 2011, p. 383). As a result of this cross-case analysis (Khan and VanWynsberghe, 2008), several overarching themes were identified. The findings below report on the themes themselves with conclusions representing our research synthesis.

RESULTS AND DISCUSSION

This section presents six main themes that emerged as a result of the research synthesis. These findings are: congruent definitions of CSL in preservice science teacher education are evident in the literature, meaning the existence of an emerging consensus among researchers and teacher educators alike. A second finding is that there are different models for applying CSL in preservice science teacher education. The third finding is that preservice science teacher outcomes associated with CSL appear favorable for them. Related to this finding and fourth, is that scant drawbacks with CSL in preservice science teacher education are being under-reported. The fifth finding is that critical reflection is a major learning strategy across courses. Sixth and finally, case study is the most common research methodology, especially in situations where the researcher is the instructor of the course under study. The findings are outlined in terms of their significance to conceptual frameworks for new teacher education programs embarking on a CSL component.

CSL Definitions Are Similar in Preservice Science Teacher Education

In general, CSL is broadly defined as a pedagogy that engages preservice science teachers in activities that meet community needs (Chinn, 2006; Jung and Tonso, 2006; Haines, 2010; Handa and Tippins, 2012). It is distinguished from volunteering experiences with its incorporation of "explicit learning experiences" (Kim, 2010, p. 322) that hold potential for preservice science teachers to improve their understanding of concepts related to teaching and learning in community and, in doing so, fosters better quality teaching. Kim (2010) further differentiates service learning from "community service" by suggesting that analysis and reflection on one's own teaching and students' learning, attends the former. Our analysis supports this contention.

Notwithstanding apparent agreement on the broader definition of CSL as a pedagogy among the articles reviewed, the purposes for using CSL as a teacher education pedagogy were only somewhat varied including: (a) applying course content in a community setting (Owens and Foos, 2007); (b) forming a learning community (Ronen and Shemer-Elkiyam, 2015); (c) gaining (technical) knowledge and skills related to pedagogy, and (d) learning about community and complex social issues (Barton, 1999, 2000; Cox-Petersen et al., 2005; Cone, 2009b,c; Kim, 2010; Lawrence and Butler, 2010; Riley and Solic, 2017). Underscoring this limited variation in purposes were shared notions of civic responsibility and strengthening communities (Borgelt et al., 2009; Haines, 2010) and how important these shared notions were to developing pedagogical skills in pre-service teachers (Chin, 2004; Cone, 2009a).

Different CSL Models Are Evident in Preservice Science Teacher Education

The studies analyzed employ different models to integrate CSL within a broader program of preservice science teacher education. The most common framework (11 articles), involves a "one-on-one model" with the inclusion of CSL within a single science methods course in the form of an after-school program wherein preservice science teachers have opportunities to work one-on-one during their course with children in community settings (Barton, 1999, 2000; Hammond, 2001; Chin, 2004; Cox-Petersen et al., 2005; Jung and Tonso, 2006; Cone, 2009a,b,c; Kim, 2010). For example, in VanWynsberghe and Khan (2014) study, preservice science teachers participate in an after-school club to help secondary students with their science homework.

Another model involves pairing science methods courses with other disciplines in an interdisciplinary and collaborative field experience (Carr, 2002; Cox-Petersen et al., 2005). Carr (2002) studied a "Science Outreach" program that brought together introductory science majors and elementary education majors who team together and teach science as a service to local and homeschooled children (Carr, 2002). In a second interdisciplinary approach, Cox-Petersen et al. (2005) integrate

CSL into their methods courses that focused both on science and language literacy. In their case study, preservice science teachers in two different sections of science and language arts methods classes develop inquiry-based literacy lessons and taught them to children in an after-school program. In both cases, the preservice science teachers report an increase in preservice teachers' confidence in teaching both science and language arts and an increased ability to plan and implement collaborative inquiry-based lessons. Kim (2010), integrates four different service-learning activities into an elementary science teaching methods course that includes the involvement of graduate students interested in language learning. Kim has preservice science teachers participate in CSL contexts where they: (1) help elementary students complete their science fair projects in a local public school, (2) present authentic science experiments to the elementary students and parents (3) present their science fair projects to middle school students, and (4) help English language learners in second grade complete their science fair projects. Pairing with another subject area, such as language arts and English language learning fosters, in some capacity, an interdisciplinary collaboration that can meet community needs and instantiate CSL.

Several offerings of CSL appear to model and support the continued content area development of preservice science teachers. For example, Haines (2010) helps preservice science teachers develop content knowledge in the area of ecology (i.e., rain forest fragmentation, nutrient cycling) in their CSL course. Preservice science teachers attend workshops on ecology before going out into community. These preservice science teachers then visit areas of ecological importance in Costa Rica and engage in observations (noting farming practices of local people), fieldwork (assisting the local farmers) and lesson planning (designing an exemplary unit on ecological concepts) as part of their CSL experiences. (Owens and Foos, 2007) studied a collaboration between a science educator and a geology instructor in a geology course. The aims were to provide future teachers with real-world and engaged scientific research experiences on the local park's resource management issues. The above courses mark a departure from research exclusively focused on science teaching methods. Instead the research on these courses reveals a focus on a science content domain of curricular significance. Moreover, and like some courses mentioned earlier, these courses paired science teaching with another discipline, thus expanding the range of subject matter knowledge available for preservice teachers.

While the majority of models for CSL occurred within single teacher education courses, Handa's et al. (2008) study includes CSL in a community immersion experience. This community immersion experience involves preservice science teachers' living in a rural community in the Philippines, known as barangay, or territorial and political units. The preservice science teachers engaged in science-related community projects in local schools and were engaged in a variety of community-building and educational strategies, such as: trust-building activities, multi-stakeholder collaboration, rapid community assessment, action research, memory banking, co-planning and co- teaching, reflection, and portfolio assessment. This multi-faceted course requires considerable coordination and agreement among teacher educators and community partners and expands the range of possible outcomes for preservice teachers.

Finally, different models of CSL appear to reflect the programmatic goals of a preservice teacher education course. For example, some models promote the learning of science content such as ecology, others diversity, practice in science fairs, or to support with language learning. Relatedly, some models can be described as full immersion in a different setting, field trip to a site, or regular periods of after or out of school engagement in organizations. The different models of CSL appeared to meet the variety in community needs.

Preservice Science Teachers' Engagement With CSL Is Reported as Mainly Beneficial

Studies that investigate the use of CSL pedagogy in preservice science teacher education contexts report a range of teacher outcomes including: gains in teachers' understanding of scientific knowledge, appreciation for scientific inquiry, and an overall capacity for articulating how to do science (Barton, 1999; Cox-Petersen et al., 2005; Owens and Foos, 2007). In addition, studies noted positive changes in self-efficacy, self-worth, and confidence among pre-service teachers (Cox-Petersen et al., 2005; Thompson et al., 2007; Cone, 2009a,b; Kim, 2010).

Here, and in light of the focus of this special issue, it is particularly important to emphasize the issue and challenge of diversity. The research documents the fact that the integration of CSL into a preservice science teacher education course is to help preservice science teacher's appreciate diversity and develop greater competencies for teaching in multicultural communities. In short, studies found that CSL builds teaching capacity in multicultural and diverse contexts, especially ones different from some of the preservice teacher's own backgrounds (Barton, 1999, 2000; Chinn, 2006; Handa et al., 2008; Cone, 2012).

More than half the studies in the synthesis examined preservice science teachers' understanding of multiculturalism, issues related to diversity, and equitable science teaching practices (Barton, 1999, 2000; Hammond, 2001; Carr, 2002; Cox-Petersen et al., 2005; Chinn, 2006; Pappamihiel, 2007; Cone, 2009a,b,c; Haines, 2010). Several of the purported intercultural competencies acquired included: conducting surveys that are sensitive enough to ascertain community needs (cf. Owens and Foos, 2007; Handa et al., 2008; Handa and Tippins, 2012) and developing culturally relevant lessons (Barton, 2000; Hammond, 2001; Chinn, 2006). Related outcomes associated with social context and community engagement in CSL included making personal connections with people unlike themselves (cf. Barton, 1999, 2000; Carr, 2002) and reinforcing multicultural education within science teacher education (cf. Cone, 2009a; Haines, 2010). For example, in Barton's (2000) detailed study, preservice science teachers undertook CSL activities to teach science collaboratively to children in a homeless shelter. More is explained below.

Benefit 1. Preservice Science Teachers Improve Their Understanding of Science and How to Teach It

By engaging in CSL activities, preservice science teachers were said to enhance their understanding of scientific phenomenon and processes of inquiry (Jung and Tonso, 2006; Owens and Foos, 2007; Borgelt et al., 2009; Haines, 2010; Kim, 2010). For example,

Chin (2004) integrated CSL into a science methods course where preservice science teachers engaged in CSL activities in a science museum. Participating in the teaching activities of the science museum, preservice science teachers reportedly developed an understanding of the science concepts that were embedded in exhibits.

Similarly, in Owens and Foos's (2007) study, preservice science teachers participated in CSL as part of a geology course, that involved working in research teams on resource management projects within parks in the region. The findings indicated that preservice science teachers improved their understanding of science as inquiry by conducting research projects and submitting reports to their Metro Park agency. Similarly, by involving preservice science teachers in a range of CSL experiences (e.g., teaching science at the science museum or nature centers), Jung and Tonso (2006) found that preservice science teachers self-reported gains in their content knowledge of science.

Haines (2010) created a CSL component in an "environmental education and service learning in the tropics" course where preservice science teachers (e.g., elementary education and secondary education majors) as well as students in other majors (e.g., environmental science) worked on sustainability projects, and learned about ecology with this experience.

In terms of building the requisite skills for teaching, CSL appears to enable preservice Science to learn how to teach science (Chin, 2004; Thompson et al., 2007), generate interdisciplinary science lessons (Cox-Petersen et al., 2005), and produce culturally-responsive curricula (cf. Barton, 2000; Hammond, 2001; Haines, 2010). Using CSL to teach science methods enabled Chin (2004) to use the meseum context to help preservice science teachers become aware that student learning and teaching processes occur in different learning environments. Moreover, they developed their ability to integrate a variety of resources, such as museum exhibits, into their lesson planning and became aware of multiple assessment methods to evaluate student learning.

Thompson et al. (2007) analyzed surveys that gauged both preservice teachers' attitudes toward science and general satisfaction with CSL. The authors reported positively, explaining that the preservice teachers viewed CSL (specifically teaching a mini-lesson) as one of the best experiences in the class; more instructive than the labs and experiments in the earth science course for them.

Analyzing preservice science teachers' collaborative portfolios, written reflections, and lesson plans, Cox-Petersen et al. (2005) concluded that CSL made positive contributions to preservice science teachers' ability to plan and implement after-school science lessons that integrated language arts. Our review of the research revealed that foundational teaching skills were reported as enhanced with CSL (Hammond, 2001; Kim, 2010; Lawrence and Butler, 2010).

Benefit 2. Preservice Science Teachers' Appreciation of Diversity and Multicultural Contexts

The preservice science teachers found it challenging to teach children who grew up unlike themselves. Specifically, CSL challenged, "[T]heir definitions of and uses for science, culture, student experience in their teaching" (p. 815). In some other studies, preservice teachers' engaging with English language learners and at-risk students suggests that the CSL experience is associated with the development of teacher sensitivity to diversity (Cox-Petersen et al., 2005; Pappamihiel, 2007). For example, Pappamihiel's (2007) English Language Learners (ELL) course encouraged preservice science teachers, "[T]o think beyond ethnocentric perspectives of interculturalism to more ethnorelative points of view, to begin to value differences between cultures and see not only the challenges of working with ELL students, but also the benefits" (p. 53). Pappamihiel reported that preservice teachers at some level appreciate some of their prejudices against these students and changed their attitudes toward more positive ones. Chinn's (2006) study in Hawaii emphasized preservice teachers' development of cross- cultural competencies as evidenced by their ability to generate locally relevant science curriculum.

Cultural translators were employed in the Chinn (2006) study to help the preservice teachers gain an insider perspective and according to the author, synthesize knowledge systems. Notably, deficit perceptions of Hawaiian students as difficult to teach were discarded in ways that, according to a preservice teacher, went beyond what, "[A]ny new teacher orientation program could" (p. 390, Chinn, 2006).

Several hypotheses about the ways CSL contributed to more equitable science teaching practices exist. Cone (2009a,b,c) investigates CSL activities where preservice science teachers create new lessons and teach science to diverse student groups at a neighborhood community center. Using questionnaires and interviews, Cone (2009a,b) found that CSL, when supplemented with explicit discussions and class activities about diversity, has a significantly positive influence on preservice science teachers' perceptions of their ability to teach science to all children, irrespective of their sociocultural background. In another well-detailed case study, Hammond (2001) investigated the collaboration among multicultural teacher educators, preservice science teachers, and teachers, students, and community members in an urban California elementary school. These different groups created science curricula to construct a Mien-American house. Hammond (2001) indicates that such an activity teaches preservice science teachers to work in communities to, "[S]upport bilingual and multicultural mentor teachers in their efforts to incorporate minority parents and community knowledge into their curricula" (p. 986). In a rare examination of the effects of CSL beyond the teachers, Hammond noted that parents became new advocates for instruction within a school system. Overall, the literature reviewed reveals that CSL helped preservice science teachers to reflect upon teaching culturally diverse students, thus providing them an opportunity to change deficit models of interacting with and teaching diverse students.

Scant Reporting of Drawbacks With CSL in Preservice Science Teacher Education

Analysis of the research revealed that studies mainly emphasized the benefits of CSL without noting problematic issues, such as: institutional barriers, integration issues with course work, unwarranted conclusions about community, lack of optimal science teaching environments, reinforcement of the status

quo, buy-in among preservice teachers, and the possible manufacturing of need and service. The challenges that were reported; however, included: (a) the potential of viewing CSL as a "tourist" experience and not as science education (Handa et al., 2008); (b) focusing on the experience and not the content of a particular topic (Handa et al., 2008); (c) anxieties due to the lack of experience working with children (Cone, 2009a; Kim, 2010), (d) limited experience with travel (Haines, 2010), and (e) problems scaling-up CSL more widely (Barton, 2000).

Barton (1999), in her valuable case study on crafting multicultural science teacher education, investigated preservice science teachers' changing views of multicultural science education in a methods course where preservice science teachers worked with children in a homeless shelter. In a follow-up paper (2000), she suggested that the CSL experience provided preservice science teachers with opportunities to separate, "[S]cience, teaching and students … from 'schooling'" (p. 815), and question how "multicultural science education" might become "regular science education."

Kim (2010) describes preservice science teachers as anxious about CSL activities during the first few weeks because of their lack of experience in conducting inquiry with children. The common question [among preservice science teachers] was, "How are we going to do that?" They were unsure of how a service-learning activity was going to turn out and felt nervous because they thought they would not have enough information to keep students interested (p. 327). To eliminate potential anxiety among preservice science teachers at the outset, Kim suggested providing an orientation to the social context of the school with clear goals and outcomes. A second difficulty presented by Kim (2010) was preservice science teachers' lack of motivation to participate when CSL was offered as an optional assignment. Kim suggested making CSL a required assignment with an attendant reduction in other course activities.

In another context, Carr (2002) details a study where CSL fosters interdepartmental collaboration between science and teacher education departments. For a science outreach program, science majors and preservice science teachers co-taught science courses to local and homeschooled children between the ages of 6–8. Using an action research methodology, Carr (2002) collected data through field notes, interviews, student work, self-reports, and an online survey from the students and faculty members in science and education. Analyses indicated that the participants initially experienced stress and tension in relation to the collaboration, however, it slowly abated over the 18-month period. Collaboration is not unique to CSL; however, challenges may be exacerbated because it is often necessary to work with multiple stakeholders.

Cone (2009b) cited qualitative data in reporting on a decrease in teacher confidence after participating in CSL. While the vast majority in their study on CSL reported an increase in confidence, a few preservice science teachers shared sentiments, such as:

> I would say I'm less confident than before. I've learned that many schools, especially in the inner city, don't have as much science equipment… I would hope that wouldn't hinder my teaching abilities to minorities or to majorities I am a little nervous simply because I don't feel confident in science (p. 378).

There are at least two possible explanations regarding a decrease in self-confidence in a few. Preservice teachers may enter the CSL experience with low levels of efficacy and confidence about teaching science to diverse students. Low levels of efficacy could be magnified after being placed in unstructured or unsupervised teaching environments. Second, and alternatively, preservice teachers might have entered the CSL experience with unrealistic optimism about teaching science to diverse students and this optimism was challenged during the CSL experiences. Holding onto this critical finding, Cone (2009b) further commented about a decrease in self-efficacy noted in the survey data:

> A question that arises from the decrease noted in PSTE [Personal Science Teaching Efficacy scale] is whether the superficial and cursory discussions and activities about diversity left preservice teachers with an inability to connect science content to students' everyday livedexperiences, thus contributing to the magnification of preservice teachers' limited science content knowledge with diverse student groups (p. 379).

Cone recommends that small group instruction utilizing non-school settings with explicit diversity assignments and discussion in the methods course. Doing so in CSL provides preservice teachers with the opportunity to interact with diverse student groups without the restrictions imposed by traditional school structures and hierarchies (Irvine, 2003).

The scalability of CSL activities in preservice science teacher education programs was also raised as a challenge to CSL integration (Barton, 2000). Providing CSL to all preservice science teachers in a program requires vision, planning, coordination, and collaboration. Barton (2000), for instance, had eight preservice science teachers in the methods course where she integrated CSL and noted that she would not be able to provide adequate support to these students if she had a larger class size:

> It would have also been difficult to manage more than eight adults in the same 'learning setting' with 15 to 20 children. [W]e need to figure out more and different ways to provide preservice teachers with out-of-school, yet still guided, collaborative opportunities to craft multicultural teaching practices in science (p. 818).

Similarly, Cone (2009a) argued that, "[A]lthough it may be argued that small group instruction in a non-school setting is unrealistic in the U.S. education system and creates a disconnect between the reality of public schools and the ideal world…these types of experiences should be required components of teacher education courses" (p. 32). For science teacher education, Cone proposes that CSL forms a pathway to truly achieving scientific literacy for all.

The preservice science teacher education literature generally considers CSL a beneficial approach in providing preservice science teachers the experiences that they do not commonly acquire in their traditional teacher education programs. Importantly, of those studies that did report these challenges, a number of them offered feasible suggestions to overcoming any negative associations of CSL on preservice science teachers.

CSL Is supported With a Spectrum of Teaching and Assessment Strategies

Analyzing the pertinent literature revealed several main strategies for integrating and assessing CSL in preservice science teacher education. These teacher education strategies included: (a) scaffolding, (b) reflecting on practice, and (c) qualitative forms of assessment. These supportive teaching strategies enhanced the CSL experience, as described more fully below.

Scaffolding Activities

Several investigations of CSL in preservice science teacher education employed structured scaffolding for preservice teachers to systematically engage with their service experiences. Scaffolding is support that is provided at the appropriate level with an eye to continued learning. Scaffolding was provided in various forms in the literature reviewed, such as facilitated discussions of diversity and fieldwork (cf. Cone, 2009a,b) and pre-CSL activities on assessing community needs (cf. Barton, 1999; Handa et al., 2008). Barton (2000), for instance, used a series of weekly meetings, "[T]o challenge and support each other's experiences; read and discuss papers related to homelessness, multiculturalism and science education as it directly related to their work at the shelter, and collaboratively plan for and reflect on their teaching" (p. 805).

The pedagogical nature of the CSL experience and, specifically, learning how to be in community, was another important theme in scaffolding activities. Handa et al. (2008) had preservice science teachers conduct surveys to learn more about the community, context, culture and people they were immersing themselves in. Owens and Foos (2007) used an orientation to build the context-related skills necessary to conduct a research project on resource management in parks. All examples feature a stepwise progression in learning the context and research techniques.

Reflections

The studies emphasized reflection as a critical component of community service learning, and so while it might be also considered a way to scaffold learning, it bears special mention here. Reflecting on the experiences involved, for example, "[M]onitor[ing]…thinking processes as well as facilitat[ing] the connection between service and learning" (cf. Cox-Petersen et al., 2005, p. 25). Reflection processes also employed: digital narratives, where preservice science teachers prepared digital stories that reflected on their learning within the community (Borgelt et al., 2009); class debriefing sessions to discuss CSL experiences (Barton, 1999; Chinn, 2006); daily or weekly written narratives linking the CSL activities and their applicability to science teaching (Cox-Petersen et al., 2005; Kim, 2010), and e-mail memos to make connections between their CSL projects and the nature of science (Owens and Foos, 2007). Of the three most common strategies employed in CSL coursework, the synthesis revealed that reflection was notably relevan to CSL's success in preservice science teacher education. Seven out of 25 articles explicitly analyzed pre-service science teachers' reflective practices during their CSL experiences (cf., Cox-Petersen et al., 2005; Owens and Foos, 2007; Pappamihiel, 2007; Cone, 2009a,b,c; Lawrence and Butler, 2010).

Varying Assessment

CSL-related assessment methods in pre-service science teacher education courses vary. The methods found include: teaching portfolios (e.g., lesson plans) (Chinn, 2006), reflections (e.g., community needs), self-assessments (e.g., teacher learning), learning artifacts [e.g., student's learning (cf., Cox-Petersen et al., 2005; Chinn, 2006; Handa et al., 2008; Kim, 2010; Lawrence and Butler, 2010), standardized assessments of content knowledge or self-efficacy (Owens and Foos, 2007; Cone, 2009a,b), technical memos (Owens and Foos, 2007), final reports (Owens and Foos, 2007; Haines, 2010), surveys (Thompson et al., 2007), and observations (Barton, 1999; Cooper, 2007).

Ethnography and Case Study Are the Two Most Common Research Methodologies

This research synthesis revealed common research methodologies followed by CSL researchers. Out of 25 studies, 7 of them explicitly labeled and described the research methodologies employed. Among these, 3 of them used case study (Barton, 1999, 2000; Cox-Petersen et al., 2005) and 1 narrative case study (Hammond, 2001), 1 action research (Carr, 2002), 1 collaborative action ethnography (Handa and Tippins, 2012) and 1 ethnography (Jung and Tonso, 2006). Seven other studies, while they did not label their research methodologies, described data collection and analysis procedures that were synonymous with survey or mixed methods research (cf. Cone, 2009a,b,c). Others could be viewed as case study research, according to VanWynsberghe and Khan (2007) prototypical features of a case study (i.e., small sample sizes, contextual details, natural settings, boundedness, working hypotheses and lessons learned, multiple data sources, and extendability). The case studies emphasized different features. Lawrence and Butler (2010) offer rich details, with their small sample size. Borgelt et al. (2009) provide contextual details of both the CSL settings and the teacher education courses. Kim (2010) took care in describing the boundaries of the research's applicability, something case study researchers call boundedness. Chin (2004) drew upon multiple data sources in delineating the common features of the case studies investigated.

Among the studies reviewed, the dominant research model is one where the instructors of the CSL courses were also the researchers. They tended to conduct case studies of their own courses and their largely qualitative findings were mainly reported in terms of positive outcomes of course-based CSL. Only 1 study offers detailed information on the researchers themselves (Handa and Tippins, 2012) and no study reported on the role of the researcher in the research context beyond noting their double role as instructor and researcher. Missing were instructors' values and beliefs, especially in regards to CSL philosophy and pedagogy. These play an important role in the research process and, as a result, the literature under-reported issues related to reflexivity, credibility and transferability and this might detract from the broader applicability of the case studies.

Research Implications and Recommendations for Future Research

In order to inform our understanding of the current state of some CSL research on preservice science teacher education, the authors undertook a systematic review of 25 articles that reported on the use of CSL as an approach in preservice science teacher education contexts. The review revealed six main findings: (1) CSL definitions in preservice science teacher education are congruent but their attendant features are not; (2) the one-on-one model within a single science teacher education course was the most common model of CSL; (3) preservice science teachers' CSL engagement fostered many benefits to them, (4) challenges exist with CSL, however few articles listed them; (5) reflection, along with other teaching strategies, are typically employed to support the CSL experience, and finally, (6) ethnography and case study were the two most common research approaches to the study of CSL, where researchers were also the instructors of the CSL course under investigation.

CSL has been undertaken as a pedagogical approach for developing capacities to understand students, communities, and roles as skillful science teachers (Wilson et al., 2015). In the literature, "[M]uch service-learning curricular integration has occurred without the benefit of a theoretical foundation broad enough to encompass the diversity of service-learning goals, practices, and outcomes" (Anderson et al., 2001, p. 1). The recommendations below, can contribute to discussions on shaping the future direction of CSL research foe science teacher education.

More Data on CSL Is Needed

All 25 studies reviewed reported that CSL is associated with benefits and enhanced outcomes for preservice science teachers. While such benefits were commonly reported, we recommend an expanded data corpus, especially one that relays the drawbacks of CSL with a section devoted to this topic (Spector et al., 2019). Comparison of the available research showed that a predominant focus of investigations on CSL in preservice science teacher education courses was on knowledge of teaching science in equitable ways to diverse groups. Indeed only 5 studies out of 25 focused on other matters such as: balancing science content with students' cognitive abilities, language issues, and using inquiry-based science (cf. Chin, 2004; Jung and Tonso, 2006; Thompson et al., 2007; Kim, 2010; Lawrence and Butler, 2010). Based on this synthesis, a call for more research on CSL and expanding its relationship to additional outcomes should be considered.

Additional Strategies for CSL Integration Could Be Investigated

The synthesis identified the most common teaching strategy associated with CSL integration in science teacher education courses as reflection. The course assessments of the CSL experience were also largely qualitative. These methods leave room for additional (and creative) teaching strategies to be explored to promote a positive CSL experience in the course, such as: modeling, role-play, and the use of case methods. It is recommended that research continue to investigate how different types of CSL projects, time requirements, and CSL contexts have an impact in the way preservice science teachers develop desired outcomes (e.g., content knowledge, pedagogical skills, affective dispositions, orientations toward diversity and community).

A Systemic Investigation of CSL in Preservice Science Teacher Education Is Needed

More research and therefore greater insight into CSL has the potential to support more system-wide adoptions of CSL in the area of science teacher education. While the research mainly includes the investigation of CSL within individual teacher education courses, further research on CSL within an entire teacher education program is needed (Feiman-Nemser, 2001). Erickson and Anderson (1997) suggest different ways for CSL to be integrated into teacher education programs beyond the single course. Examples include the infusion of CSL into the practica (Chin, 2004), or throughout a teacher education program, such as the integration of CSL into middle-level teacher education at California State University-San Marcos (Stowell and McDaniel, 2001). Simultaneously exploring CSL in professional development might suggest an important extension of the preservice science teacher education experience (Darling-Hammond et al., 1995; Hammond et al., 2009).

Research Must Also Investigate the Impact of CSL on Community and Children and Parents

Not surprisingly, the literature on CSL and preservice science teacher education primarily reported only outcomes related to preservice science teachers. Notable exceptions involved special attention to stakeholder outcomes, such as community partners' perceptions and children's learning (cf. Hammond, 2001; Carr, 2002; Handa et al., 2008; Lawrence and Butler, 2010). For example, Carr's interdisciplinary course helped science majors learn more about preservice teachers' perspectives of science and how to teach it. Hammond's (2001) extensive study discussed how Mien parents became advocates for the garden project and began to attend school events in larger numbers. Studies that unearth community perspectives and children and parents' learning would be significant contributions. Longitudinal studies may help in this regard to better locate the broader impact of CSL on preservice science teachers' knowledge and practice, children's learning when CSL is enacted in their classrooms, and desired community outcomes.

Future Research on CSL Should Expand on Methods

Researchers investigating CSL in preservice science teacher education use a variety of research methods, including: case study, surveys, and ethnography. Comparatively far fewer studies reported on preservice science teachers using quantitative measures from standardized instruments (Cone, 2009a,b,c) or quantitative surveys (Carr, 2002). Anecdotal reports on CSL experiences within preservice science teacher education courses were also evident in the literature. While these reports hold value in sharing the variety of CSL experiences, additional empirical investigations would be useful to extend how CSL could be transferable to other contexts. These case investigations

could provide a source for comparing CSL cases to help us understand the phenomena of interest in preservice science teacher education.

Much of the research reviewed was where: "[T]he service-learning instructor has been the sole investigator responsible both for the administration of measures and data analysis, procedures that permit observer effects and interpretive bias" (Root and Swick, 2001, p. 148). Explicit discussion of the trustworthiness of the studies and more transparent information about the analyses used to investigate teacher practice within CSL settings would expand our understanding of how one could conduct research in this area. For example, direct quotations from members and photographs with permission (cf. Chinn, 2006) might enhance trustworthiness. In addition, the interpretations of CSL researchers could be triangulated by the informants, and in doing so, also enhance the integrity of the data. Future research could also include perspectives of community staff in order to see how their experiences affirm or differ from instructors or pre-service teachers.

Indeed, where the CSL researcher is also the course instructor, further discussion is encouraged on how the information provided by research participants and stakeholders was specially interpreted, from the standpoint of the researcher. Collectively, CSL research in science teacher education would benefit with an expanded and specific section devoted to its methods.

Ethical Concerns Need to Be Reported

Root and Swick (2001) suggest that the principles of consent and privacy and ethical concerns, more generally, should guide the research on CSL. Studies did not always report, for example, on the steps taken to inform participants, such as children and community partners. An advanced discussion on the ethical principles guiding CSL research, on topics such as autonomy (i.e., procedures of informed consent), confidentiality, anonymity, and justice (i.e., recognizing participants and their contributions to the research), would be especially beneficial to those seeking insights on CSL. In summary, ethical concerns regarding CSL are not unique to science-oriented CSL experiences; however, we are reminded that issues of consent, privacy, and stereotyping continue to need to be reported in studies on CSL.

As suggested by Anderson et al. (2001), "[S]ervice learning in preservice teacher education needs to develop a knowledge base of shared understandings regarding definitions, rationales, principles of good practice and theoretical underpinnings" (p.x); the research reviewed herein provided evidence that the literature on CSL in preservice science teacher education are not in full agreement on the conceptualizations and principles of CSL. In the absence of definitional clarity, it is also challenging to evaluate the knowledge contributed to teaching practice. Future research regarding CSL must make clear the underlying assumptions being made about knowledge and practice. Only through such clarity, we assert, can CSL itself be well-understood. The literature reviewed posits CSL as a worthwhile consideration for science teacher education programs because it can provide rich learning opportunities and practical experience to preservice science teachers.

It is appropriate to reinforce the fact that among the peer reviewed publications reviewed there was strong sentiment encouraging the use of CSL in preservice science teacher education in order to challenge deficit model of vulnerable students. For example, Gonzalez et al. (2005) suggests facilitating dialogue regarding culturally diverse families, practicing self-reflexivity in ongoing work in the community with careful attention to discourses of deficit, and providing opportunities for preservice teachers to engage in home visits to encounter their cultural resources. Other suggestions include performing case studies of one child throughout an extended period both in school and home contexts and requiring the creation of culturally responsive curricula to teachers (LaMaster, 2001; Darling-Hammond and Berry, 2006; Baldwin et al., 2007; Lowenstein, 2009; VanWynsberghe and Khan, 2014).

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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