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Boundary Crossing in a Professional Association: The Dynamics of Research Use Among State Leaders and Researchers in a Research-Practice Partnership

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As spaces for researchers and practitioners to engage in long-term, mutual collaborations aimed at addressing problems of practice in education, research-practice partnerships (RPPs) offer rich contexts for research use. Our study examines how interactions between researchers and practitioners shape opportunities for research use in a professional association engaged in RPP activities focused on fostering change in statewide K–12 science education. Drawing on a conceptualization of RPPs as joint work at boundaries, we show how both researchers and practitioners facilitated research use. Furthermore, research use was facilitated by brokers' engagement in RPP activities and with shared pieces of research. Findings affirm the role that brokers play in connecting research and practice and identify specific activities that may be useful in facilitating research use in RPPs.

Keywords: *boundary crossing, descriptive analysis, policy, professional associations, research practice partnerships, research utilization, science education, survey research*

In light of persistent gaps between research and practice, education stakeholders have called for the development of bidirectional, interactive relationships between researchers and practitioners (Bryk, 2015; Coburn & Penuel, 2016; Gutierrez & Penuel, 2014). In bidirectional relationships, evidence-based information related to defining, implementing, and studying improvement efforts flows between practitioners and researchers, as opposed to relying on unidirectional transference from research to practice (Penuel, Allen, Coburn, & Farrell, 2015). Furthermore, both researchers and practitioners are viewed as sources of research-based expertise (Coburn, Penuel, & Geil, 2013). These bidirectional relationships are important for ensuring that research is developed and used in ways that are relevant to problems of practice, is actionable, and can inform decision making by both parties (Desimone, Wolford, & Hill, 2016). Indeed, research use is an inherently social phenomenon (Daly, 2012; Daly, Finnigan, Moolenaar, & Che, 2014; Neal, Neal, Kornbluh, Mills, & Lawlor, 2015; Penuel et al., 2015), influenced by the norms and work practices of practitioners and researchers, as well as the nature of their interactions (Farrell & Coburn, 2017; Farrell, Coburn, & Chong, 2018).

Our study examines how interactions between practitioners and researchers in a professional association shaped opportunities for research use. We focus on state education agency (SEA) leaders and researchers engaged in research-practice partnership (RPP) activities aimed to foster change in statewide K–12 science education. As spaces for researchers and practitioners to engage in long-term collaborations aimed at addressing pressing problems of practice, RPPs offer rich contexts for examining research use in education (Coburn et al., 2013; Coburn & Penuel, 2016). By design, RPPs emphasize both researcher and practitioner expertise in supporting change (Rosenquist, Henrick, & Smith, 2015), and do so by "negotiating the focus of joint work, uncovering key drivers for improvement, structuring co-design processes, and sharing and interpreting findings from research studies" (Coburn et al., 2013, p. 3). Given that research is meant to be generated with and for practitioners, RPPs represent a departure from traditional scholarly research, which often aims to address gaps in existing research or theory, and relies on practitioners to translate research findings (Henrick, Cobb, Penuel, Jackson, & Clark, 2017; Penuel et al., 2015; Wentworth, Mazzeo, & Connolly, 2017). Although we foreground RPPs as a model for shifting who participates in the design and production of research, it is important to note that several approaches foster bidirectional relationships between researchers and practitioners, such as continuous improvement and design-based models (Anderson & Shattuck, 2012; Cohen-Vogel et al., 2015), as well as participatory action

research and community-based research models (Cammarota & Fine, 2008).

Scholars examining research use in RPPs point to several factors that make collaboration between researchers and practitioners challenging, such as differing goals, expectations, and routines (Penuel et al., 2015). Scholars have suggested that brokers (also referred to as boundary spanners or intermediaries) can be helpful in bridging these differences (Farley-Ripple, May, Karpyn, Tilley, & McDonough, 2018; Neal et al., 2015). As individuals who cross boundaries between research and practice, brokers may be well positioned to facilitate research-practice connections, creating a "third space" where the scope and goals of collective work are jointly negotiated (Farley-Ripple et al., 2018; Penuel et al., 2015). Several recent studies in districts and schools have highlighted the importance of brokers for knowledge sharing and research use (e.g., Daly et al., 2014; Lin & Chiou, 2015; Neal, Neal, Mills, Lawlor, & McAlindon, 2019), and one recent study described how brokers facilitate state leaders' access to research (Hopkins, Wiley, Penuel, & Farrell, 2018). We build on this work to examine how brokers facilitated research-practice boundary crossing among state-level practitioners and researchers in a professional association. We examine who brokered research among SEA leaders and researchers, whether and how professional association activities facilitated such brokerage, and the kind of research shared across association members.

Our focus is on research-practice boundary crossing among members of the lead professional association for state science education leaders in the United States, the Council of State Science Supervisors (CSSS). CSSS includes SEA leaders in science education from all 50 states and the District of Columbia, past SEA leaders, and a small group of affiliates from universities and intermediary organizations. The inclusion of researchers in CSSS is a recent development that potentiates interactions between practitioners (i.e., SEA leaders) and researchers, and thus affords opportunities for boundary crossing between research and practice (more on this below). Our focus on state leaders adds to the prior literature on RPPs, which tends to focus on relationships between researchers and school or district leaders (Coburn et al., 2013; Coburn & Penuel, 2016). State-level explorations are important, given that the role of SEAs in the United States has expanded with respect to developing infrastructures that inform practice statewide (Farley-Ripple & Jones, 2015; Smarick & Squire, 2014), and that SEA leaders face increased pressure to use research in their decisions, as outlined in the 2015 Every Student Succeeds Act (Penuel & Farrell, 2017).

In the following sections, we expand on the relevance of investigating research use among practitioners and researchers in a professional association, present our theoretical framework, and describe our research methods. Turning to findings, we show that research was brokered in CSSS by both practitioners and researchers. Furthermore, brokering was facilitated by RPP-related activities, and brokers drew on rigorous research that examined systemic issues in science education. We conclude with a discussion of the implications and limitations of our findings.

Professional Associations as Conduits Between Research and Practice

Outside education, professional associations have been described as settings that facilitate the exchange of research-based ideas, and thus as important sites for connecting research and practice (Greenwood, Suddaby, & Hinings, 2002; Hicks, Isett, & Melkers, 2017; Newell & Clark, 1990; Parada, Nordqvist, & Gimeno, 2010; Swan & Newell, 1995; Tucker & Lowe, 2014). Through conferences, networking activities, and mentoring opportunities, professional association members are exposed to effective practices that can build knowledge and skills and foment commitment to the profession (Coppin & Fisher, 2016; Parada et al., 2010). Furthermore, interactions among members can facilitate the establishment of shared norms, transform practice around shared values (Gazley, 2014; Greenwood et al., 2002), and motivate collective action, such as policy change (Parada et al., 2010).

Although professional associations are an important source of research-based information for educational leaders (Penuel et al., 2017), few studies have examined how researchers and practitioners interact in such settings, and whether and how research is used to inform change. Addressing this gap, our study focuses on a professional association where members are actively working to design statewide systems that support implementation of the vision of equitable science teaching and learning presented in the *Framework for K-12 Science Education* (*Framework*; National Research Council, 2012). The *Framework* draws on a large body of research related to how students best learn science, and calls for significant changes to curriculum, instruction, professional development, and assessment in K–12 science education (National Research Council, 1999, 2005, 2007, 2009).

Given that some 40 states have adopted standards aligned to the vision of the *Framework*, CSSS has engaged researchers in a variety of ways to guide the implementation process. Researchers are an integral part of the association's annual conference, where they are invited to present ideas related to science education and leadership. CSSS also has a variety of committees that develop research-based resources to guide SEA leaders' work (e.g., professional standards); in 2015, researchers were added to each committee, many of whom are affiliate members. Committee-developed resources are shared with members via webinars put on by researchers and SEA leaders.

In addition to these activities, CSSS has been involved in emergent efforts to investigate and address problems of

practice that arise as SEA leaders implement the ideas outlined in the *Framework*. The first effort, Building Capacity in State Science Education (BCSSE), took place between 2011 and 2014, when SEA leadership teams from nearly all 50 states came together to develop implementation plans based on the *Framework*, and brought in researchers to help them think about the shifts in science teaching that would be required, as well as the statewide organizational changes needed. The second effort, Advancing Coherent and Equitable Systems of Science Education (ACESSE) began in 2017, and brought together leadership teams from 13 states, who worked with university researchers to analyze the challenges associated with implementing the *Framework*, and to study the conditions necessary to build coherent and equitable systems of science education (Penuel et al., 2018).

These intentional strategies to bring SEA leaders and researchers together promote RPP-related work in which practitioners and researchers are engaged in a long-term collaboration focused on problems of practice in the field (Coburn et al., 2013). CSSS as a professional association thus offers a unique context to examine how interactions between researchers and practitioners in education contribute to research use. In the next section, we present the theoretical framework that shaped our examination of boundary crossing among researchers and practitioners in CSSS.

Theoretical Framework

Noting that collaborative processes between researchers and practitioners "are both messier and potentially more transformative than the one-way translation of knowledge of research into practice," Penuel et al. (2015) conceptualize RPPs as "joint work at boundaries" (pp. 183–184). Joint work occurs as researchers and practitioners interact and co-construct goals for research and improvement, which requires constant negotiation of the boundaries that separate research and practice. To examine relations between researchers and practitioners in CSSS, we follow Penuel et al. (2015) and draw on the concepts of boundary crossing, boundary practices, and boundary objects. We identified CSSS members who brokered research across research-practice boundaries (i.e., boundary crossing), examined their engagement in joint work (i.e., boundary practices), and explored the types of research they drew on (i.e., boundary objects). Doing so allowed us to explore how professional associations shape opportunities for research use in education.

Prior scholarship suggests that, for joint work to be accomplished in RPPs, participants must engage in *boundary crossing* to navigate differing norms and expectations, including the ways problems are framed, goals for collaboration, and the expected pace of work (Coburn et al., 2013; Malin, Brown, & Trubceac, 2018; Penuel et al., 2015). Boundary crossing might involve a researcher joining a meeting led by SEA leaders to discuss implementation challenges, or a SEA leader participating in a conference presentation led by researchers. In either case, the researcher and SEA leader enter unfamiliar territory in which they may not feel qualified. Penuel et al. (2015) suggested that such boundary crossing is often facilitated by individuals who demonstrate an interest in understanding and bridging cultural differences across groups. Research suggests that these individuals, referred to as brokers, act as "go-betweens" who serve the needs of both researchers and practitioners (Neal et al., 2015). Brokers can enable the exchange of resources and ideas across research-practice boundaries (Burt, 2005), thus helping close "the communication gap" between research and practice (Neal et al., 2019, p. 41). Adding to this literature, we identified individuals within CSSS who brokered research across research-practice boundaries and determined the brokerage roles they played.

To examine brokerage roles, we drew on prior studies of research-practice brokering (Hopkins et al., 2018; Neal et al., 2015; Neal et al., 2019) and used Gould and Fernandez's (1989) typology that identified five broker types: *coordinator, liaison, representative, gatekeeper*, and *itinerant*. Whereas *coordinators* broker research and research-related information between two individuals who belong to their own community, *liaisons* serve as brokers across three communities. For example, a SEA leader who brokers research between an intermediary who facilitates teacher professional development in their state and a university researcher would be a liaison (see Table 1). In this chain, not only do the three individuals belong to different communities but the brokerage chain also crosses from practice to research.

Gatekeepers and representatives, on the other hand, connect individuals from two different communities. A *gatekeeper* broker is part of the same community as the individual receiving information; thus, they can facilitate or hinder access to information in their community. For example, a SEA leader turns to a university researcher, who turns to a researcher at a nonprofit agency for research. In contrast, *representatives* send information to a community different from their own, in effect pushing out information. For instance, a SEA leader turns to another SEA leader for research, and that SEA leader seeks out a university researcher. In this example, the brokerage chain crosses from practice into research. Unlike gatekeepers and representatives, an *itinerant* broker connects individuals who belong to the same community as one another. To illustrate, an intermediary might turn to a university researcher for research, and that researcher turns to a SEA leader. In this way, the researcher brokers information between two practitioners. Examples of each brokerage type are shown in Table 1.

While brokers can play different roles in connecting research and practice, joint work among researchers and practitioners is often accomplished through *boundary practices*, or "stabilized routines, established and sustained over time, that bring together participants from different domains

TABLE 1
Brokerage Chains, by Type

Broker Type	Example	Number (%) That *Did Not* Cross Research-Practice Boundaries	Number (%) That Crossed Research-Practice Boundaries	Boundary-Crossing Chains			
				Number (%) With SEA Leader as Broker	Number (%) With Intermediary or Vendor as Broker	Number (%) With Researcher as Broker	Number (%) With External Source of Research
Coordinator	SEA leader → SEA leader → SEA leader	14 (36)	0 (0)	NA	NA	NA	NA
Liaison	Intermediary → SEA leader → University researcher	4 (10)	37 (39)	11 (30)	26 (70)	0 (0)	25 (68)
Representative	SEA leader → SEA leader → University researcher	14 (36)	27 (29)	27 (100)	0 (0)	0 (0)	15 (56)
Gatekeeper	SEA leader → University researcher → University researcher	3 (8)	30 (32)	0 (0)	0 (0)	30 (100)	10 (30)
Itinerant	SEA leader → University researcher → SEA leader	4 (10)	0 (0)	NA	NA	NA	NA

Note. SEA = state education agency; NA = not applicable.

for ongoing engagement" (Penuel et al., 2015, p. 190). Such routines incorporate cultural elements and professional practices from both research and practice, creating a hybrid space for negotiating joint work. In a school district, these routines might include the codesign of professional development (Penuel et al., 2015). In the context of CSSS, the opportunities that SEA leaders and researchers have on committees to codesign research-based resources represent a boundary practice. These boundary practices allow participants to coordinate activities across contexts, and to share common ideas or resources that serve as the basis for their joint work.

The shared ideas and resources that travel between research and practice can be considered *boundary objects* (Akkerman & Bakker, 2011; Star & Griesemer, 1989; Wenger, 1998). Boundary objects have meaning to both researchers and practitioners, and they can help coordinate activities within and across routines, or boundary practices. An example of a boundary object in a district or school might be a curricular framework that researchers and practitioners use in the codesign of professional development (Spillane, Hopkins, & Sweet, 2018). In this study, we conceptualize the pieces of research that participants named as informing their implementation of the *Framework* as boundary objects. Examining commonalities between these pieces of research among brokers allowed us to develop some hypotheses about the kind of research-based ideas that crossed research-practice boundaries in CSSS.

Overall, while prior research demonstrates that brokers can facilitate connections between researchers and practitioners, less is known about *how* brokerage contributes to research use in education. We utilized the concepts of boundary crossing, boundary practices, and boundary objects to identify brokers' roles in crossing research-practice boundaries, how RPP-related activities facilitated their boundary crossing, and the types of research-based ideas they drew on. Our research questions were (1) Who served as brokers between research and practice in CSSS, and what brokerage roles did they play? (2) What boundary practices facilitated research-practice boundary crossing? (3) What kinds of boundary objects had the potential to cross research-practice boundaries?

Method

We used data from the second year of a 2-year project designed to examine research use among CSSS members. We followed the definition of research used by the National Center for Research in Policy and Practice (Penuel et al., 2016): "as an activity in which people employ systematic, empirical methods to answer a specific question" (p. 2). Research is thus different than the practice of looking at data, which is more open-ended and seldom addresses specific research questions. As noted previously, the membership of CSSS includes both practitioners and researchers, thus presenting an opportunity to examine research-practice boundary crossing.

Sample

A survey was given to all 142 CSSS members in April 2017, which included 75 state members, 30 associate or honorary members, and 29 affiliate members, and represented 47 states and the District of Columbia. Surveys were received from 53% of state members ($n = 40$), 37% of associate and honorary members ($n = 11$), and 24% of affiliate members ($n = 7$). The overall response rate was 43% ($n = 58$), which is typical of survey-based studies (Cook, Heath, & Thompson, 2000). The final sample included members from 36 states and included a higher proportion of state members than were represented in CSSS as a whole (69% vs. 56%), and a lower proportion of affiliate members (12% vs. 22%). In terms of demographics, the sample was comparable to CSSS membership, with the majority of respondents identifying as female (60% or $n = 35$) and white (84% or $n = 49$), compared with 65% and 85% of CSSS members, respectively. In terms of education, 81% ($n = 47$) of respondents reported holding a master's degree, and 25% ($n = 15$) reported holding a doctoral degree. Even though the sample was representative of CSSS in some ways, our results should be interpreted with some caution, as it may be that our sample disproportionately reflected state members' boundary crossing, and that it tended to include highly involved CSSS members (i.e., regular participants in activities like the annual meeting where we collected data; see below).

Data Collection

We collected surveys in two ways. First, we distributed the survey at the CSSS Annual Conference in April 2017. All attendees who were willing to participate filled out a paper survey, due to the lack of Internet access. Second, we sent email messages to any individuals who did not complete the paper survey and invited them to complete an online version via Qualtrics. A maximum of three follow-ups were sent to these individuals over a 1-month period. Forty-seven respondents, or 81% of the sample, completed paper surveys, and 11 respondents, or 19% of the sample, completed the survey online. Comparative analyses of substantive results between the paper and online surveys indicated no significant differences by response type. For example, respondents were equally likely to be identified as brokers, with 23% of paper respondents serving as brokers, compared with 27% of online respondents. Additionally, there were no statistical differences ($p < .05$) on items pertaining to participation in professional association activities between paper and online respondents.

With respect to the content of the survey, it included a question that was developed and piloted in collaboration

with CSSS members, and asked respondents to name up to 12 individuals to whom they turned for research to inform their state's efforts to implement the vision of the *Framework*. Although limiting the number of responses to this question may have introduced some bias, only three respondents reached that limit, representing 5% of the sample. For everyone listed, respondents were asked to indicate their name and organizational affiliation.

Then, a set of items asked respondents to report the frequency with which they participated in various CSSS-related activities over the past 3 years. A list of activities was developed from a review of documents provided by the CSSS board, then reviewed by CSSS members. Activities included the annual CSSS conference, CSSS committee meetings, CSSS board meetings, BCSSE meetings, collaborating with other states, reviewing drafts of Next Generation Science Standards, presenting at research meetings, CSSS webinars, or reading information from the CSSS listserv. For each activity, respondents were asked how often they participated: *never* (1), *once* (2), *2 to 3 times* (3), or *4 or more times* (4).

Next, we followed an approach used in a national survey of research use (Penuel et al., 2016), and asked respondents to name a specific piece of research they used to inform decisions related to implementation of the *Framework*. For each piece of research named, we asked respondents to identify (if they could) the title, author, year published, publisher, and topic. Forty-three respondents, or 73% of the sample, provided enough information to identify the piece of research mentioned.

Data Analysis

In alignment with our framework, we first identified brokers in the sample who engaged in research-practice boundary crossing and examined the brokerage roles they played. Then, we examined brokers' involvement in boundary practices compared with other respondents, and the kind of boundary objects on which they relied.

Boundary Crossing by Brokers. We used data related to whom respondents turned for research to generate a list of all research transfer chains. These chains included instances where a CSSS member served as a broker who facilitated the transfer of information between two other individuals (e.g., $A \rightarrow B \rightarrow C$). Given the nature of our sampling approach that focused on CSSS members, the primary seeker of research (A) and the broker (B) in all chains were CSSS members and survey respondents, while the end source of research (C) was either a CSSS member or someone not affiliated with the association who may or may not have responded to the survey. Our approach thus differs from research using a small world design (e.g., Neal et al., 2019), and is limited in that we did not collect data from all persons in each chain.

To identify chains in which boundary crossing occurred, we developed a list of codes to indicate each individual's role in their professional community. We used information related to their organization and position, which we located online if it was not readily available from survey responses. Then, we applied a code to each individual for whether they were a practitioner or a researcher, and applied subgroup codes to identify each individual's professional community. Practitioners included (1) SEA leaders, (2) intermediaries whose work focused on providing professional development (as opposed to conducting research), (3) leaders of other professional associations, and (4) vendors of instructional materials. Researchers included (1) university faculty and (2) researchers associated with nonprofit agencies and think tanks.

Drawing on Gould and Fernandez's (1989) typology, we identified the type of brokerage occurring in each chain. We dropped the 39 chains that did not cross research-practice boundaries, which included all chains with coordinator and itinerant brokers (see Table 1). This process left us with 94 boundary crossing chains that were brokered by 14 individuals (see Table 2). To assess the types of brokerage in which these individuals engaged, as well as their relative prominence, we calculated the number and proportion of chains representing each brokerage role (i.e., liaison, gatekeeper, representative). Then, we examined brokerage by subgroup, and calculated the proportion of chains that included an individual not affiliated with CSSS.

Boundary Practices. We used survey items focused on participation in professional association activities to examine whether the brokers in our sample engaged in particular activities at different rates than other respondents. Using exploratory factor analysis, we found that seven of the 12 items loaded onto one factor indicative of boundary practices (see Table 3). Each item referred to an activity in which researchers and practitioners had opportunities to engage in joint work, such as at the CSSS annual meeting, via CSSS committees and webinars, during BCSSE meetings, and in other collaborative spaces. We calculated a mean score for each respondent across these 7 items; then, we compared average engagement in boundary practices between brokers and nonbrokers using a two-sample *t* test procedure.

Boundary Objects. Seventeen unique pieces of research were named by the 43 people who provided enough information for us to identify it. Following an approach employed by National Center for Research in Policy and Practice, we coded these 17 pieces of research for their form and focus. With respect to form, we identified whether each piece of research was a National Academies of Sciences, Engineering, and Medicine consensus panel report, a peer-reviewed journal article, a book, a research report, or a policy brief. In terms of focus, we coded each piece for its emphasis on one

TABLE 2
Characteristics of Research-Practice Brokers in the Study Sample

No.	Member Type	Group	Subgroup	No. of Chains
1	State	Practice	State Science Leadership	2
2	State	Practice	State Science Leadership	4
3	State	Practice	State Science Leadership	4
4	State	Practice	State Science Leadership	8
5	State	Practice	State Science Leadership	4
6	State	Practice	State Science Leadership	3
7	State	Practice	State Science Leadership	4
8	State	Practice	State Science Leadership	5
9	Associate	Practice	Vendor	7
10	Associate	Practice	Intermediary	10
11	Honorary	Practice	State Science Leadership	4
12	Affiliate	Practice	Intermediary	9
13	Affiliate	Research	University Research	19
14	Affiliate	Research	University Research	11

TABLE 3
Association Activity Survey Items and Factor Loadings

Item	Factor Loading
Please indicate how often you participated in the following activities over the past 3 years.	
Boundary practices ($\alpha = 0.84$)	
CSSS annual meeting	0.71
CSSS committee meetings	0.82
BCSSE meetings	0.69
Collaborating with members from other states	0.62
Presenting at National Academies or other national meetings	0.63
Attending workshops/talks by researchers	0.71
Participating in CSSS webinars	0.62
Other items	
CSSS board meetings	0.25
Visiting other states	0.29
Reviewing drafts of NGSS	0.28
Consulting with other CSSS members	0.24
Reading information from the CSSS listserv	0.15

Note. CSSS = Council of State Science Supervisors; NGSS = Next Generation Science Standards; BCSSE = Building Capacity in State Science Education.

of four topics: student learning and outcomes, teachers and teaching in the classroom, assessment, and school system organization, improvement, and reform.

Two of the authors independently coded four pieces of research (i.e., about 25% of the unique pieces named) and met twice to discuss any discrepancies. After establishing agreement and collaboratively coding five more pieces of research (i.e., about 50% of the pieced named), one of the authors coded the remaining pieces of research. Then, we calculated the proportion of pieces of research named that fell into each coding category to examine the extent to which brokers drew on similar sources of research, as compared with other respondents.

Findings

Both practitioners and researchers served as brokers who crossed research-practice boundaries. Of the 14 brokers identified, nine were SEA leaders (eight state CSSS members and one honorary CSSS member), two worked for intermediary organizations offering professional development services (one associate and one affiliate CSSS member), one was an instructional materials vendor (and associate CSSS member), and two were university researchers (both affiliate CSSS members). There was some variation in the number of chains brokered between these subgroups, with SEA leaders tending to broker the fewest chains (between two and eight), compared with intermediaries or vendors who brokered between seven and 10 chains, and researchers who brokered between nine and 19 chains (see Table 2).

These boundary-crossing brokers had been involved with CSSS for about the same amount of time as other respondents (i.e., about 4 years); however, they were more likely to have served in a leadership role. About two thirds of the brokers (64% or $n = 9$) were president, secretary, board member, or committee chair at some point, compared with just one-fifth of other respondents (18% or $n = 8$). Below, we describe the roles these brokers played, their engagement in boundary practices, and their use of boundary objects.

Brokering Across Research-Practice Boundaries

As noted previously, we found no instances of itinerant brokerage in the 94 research transfer chains that crossed

research-practice boundaries (see Table 1). Thus, there were no instances in which research moved back and forth between subgroups, for example, from a SEA leader to a university researcher, back to a SEA leader. With respect to other brokerage roles, liaisons were present in 39% of boundary-crossing research transfer chains, representatives in 29% of chains, and gatekeepers in 32% of chains (see Table 1).

In terms of who served in particular brokerage roles, we found that practitioners (i.e., SEA leaders, intermediaries, and vendors) were either liaison or representative brokers, whereas researchers only served as gatekeepers. Of 37 liaison research transfer chains, SEA leaders brokered 11 (30%) of them, and an intermediary or vendor brokered the remaining 26 chains (19 and 7, respectively). In all of these chains, another practitioner turned to the broker for research, and the broker turned to a researcher. In 68% ($n = 25$) of these chains, the researcher was not affiliated with CSSS.

In contrast with liaisons, who were either SEA leaders, intermediaries, or vendors, representative brokers were all SEA leaders. In all 27 representative chains, SEA leaders facilitated the exchange of research between another SEA leader and a researcher, over half (56%) of whom were not affiliated with CSSS (see Table 1). Then, of the 30 research transfer chains that included a gatekeeper, all were brokered by a researcher. In these chains, a SEA leader or intermediary turned to a researcher for research, and that researcher turned to another researcher. Unlike liaison and representative chains, where the majority included a researcher not affiliated with CSSS, gatekeeper chains included an external researcher only 30% of the time (see Table 1).

Brokers' Engagement in Boundary Practices

In terms of the activities brokers engaged in as CSSS members, results from a two-sample mean comparison revealed that, on average, the 14 brokers reported significantly more frequent engagement in activities that enabled boundary crossing than the other 44 respondents. These boundary practices included several routines that facilitated research use via engagement in joint work between researchers and practitioners, such as the CSSS annual meeting, where research ideas are shared and disseminated; CSSS committees and BCSSE meetings, where SEA leaders and researchers engaged in resource co-design; CSSS webinars organized by SEA leaders and researchers; collaborating with CSSS members from other states; and presenting or attending research-related talks and workshops.

Whereas brokers reported participating in these activities two to three times in the past 3 years ($M = 3.21$; SD = 0.55), other respondents reported participating in them just once on average ($M = 2.31$; $SD = 0.68$), a mean difference that was statistically significant ($p < .01$). On the other hand, there were no significant differences between brokers and other respondents in their reported participation in CSSS board meetings, visiting other states, reviewing drafts of science standards, consulting with other CSSS members, and reading information on the CSSS listserv. In general, these activities tended to include either researchers or practitioners, and not both, or they were not part of routines that afforded opportunities for ongoing collaboration. For example, board meetings included only SEA leaders, and consulting with other members was an ad hoc activity that did not occur on a routine basis. All survey respondents, including brokers and others, reported participating in these activities about two or three times per year.

Brokers' Use of Boundary Objects

We also found some commonalities in the type of research the brokers in our sample reported using. Thirteen of the 14 brokers (93%) indicated that they used a consensus study report from the National Academies of Sciences, Engineering, and Medicine to inform their state's implementation of the *Framework*, compared with 58% of other respondents. These reports included *Taking Science to School* (National Research Council, 2007), *Developing Assessments for the Next Generation Science Standards* (National Research Council, 2014), and *Guide to Implementing the Next Generation Science Standards* (National Research Council, 2015). Each of these reports was written by a national panel of experts from both the research and practice communities, and has been used in CSSS activities (e.g., BCSSE and ACESSE) as a resource for professional learning.

With respect to the foci of the research they used to inform their state's implementation of the *Framework*, we found that about the same proportion of the pieces of research named by brokers and other respondents focused on assessment or teachers and teaching in the classroom (about 25% and 20%, respectively). In contrast, we observed slight differences in the two other focal areas, with about 30% of brokers naming research focused on student learning and student outcomes, compared with 45% of other respondents. The remaining 25% of the pieces named by brokers focused on school system organization, improvement, and reform, compared with 10% of the pieces named by other respondents. Though these differences were not significant, they suggest that brokers may have been more likely to use research emphasizing system-level change, a topic that was central to the RPP-related work in which CSSS was engaged.

Discussion and Implications

Using the concept of boundary crossing to undergird our work, we identified individuals within CSSS who served as brokers of research related to statewide standards implementation, examined the practices they engaged in to facilitate connections between research and practice, and the pieces of research on which they drew. In this section, we discuss our findings and their implications, outline the limitations of our study, and provide directions for future research.

Researchers and Practitioners as Brokers of Research

Consistent with prior work on RPPs that highlights the importance of mutualistic, collaborative relationships (Coburn et al., 2013; Coburn & Penuel, 2016), our findings revealed that both researchers and practitioners engaged in brokering that crossed research-practice boundaries. The majority (12 of 14) of the boundary-crossing brokers we identified were practitioners (i.e., SEA leaders, intermediaries, or vendors) who served as liaisons or representatives and facilitated other practitioners' access to research used by researchers. In contrast, just two brokers were researchers who played gatekeeping roles and facilitated the transfer of research between practitioners and other researchers. These findings suggest that, although many practitioners in CSSS may not have had direct connections to researchers who could provide them with research to inform their state's implementation of the *Framework*, they did have access to research used by researchers via other practitioners in the association. Furthermore, these connections may have facilitated their access to more diverse sources of research, given that practitioners were twice as likely to serve as brokers to external sources of research than were researchers, who tended to turn to other researchers affiliated with CSSS. This finding also indicates that the SEA leaders, intermediaries, and vendors we identified as brokers may have helped infuse research-based ideas from outside CSSS into the work of the association, which prior work suggests is important for fostering innovation (Hansen, 1999; Krackhardt & Stern, 1988). In contrast, the researchers we identified as brokers may have been more likely to share ideas that were duplicative of the association's existing research base.

Although practitioners played a prominent role in brokering research among CSSS members, it is important to note that all 94 boundary-crossing brokerage chains in our study ended with a researcher. Said another way, a researcher was the ultimate source of research for CSSS members in every single research transfer chain. Furthermore, we observed no instances where a researcher identified a practitioner as someone to whom they turned for research pertaining to state standards implementation. These findings suggest that there is still work to be done within CSSS for bidirectional relationships to exist in a two-way RPP. In such partnerships, practitioners "are not mere consumers of research . . . but rather are active knowledge creators [and] leading thinkers" (Malin et al., 2018, p. 10). This kind of partnership may require researchers to assume a different stance that recognizes and values practitioners' knowledge and capabilities and that disrupts traditional power dynamics (Malin et al., 2018).

One mechanism through which two-way partnerships may develop is via engagement in boundary practices (Penuel et al., 2015). The brokers in our study reported engaging in several activities more frequently than other survey respondents that afforded them with opportunities for joint work across research-practice boundaries. These activities, which included the association's annual meeting as well as routines where researchers and practitioners engaged in the codesign of research-based resources (e.g., BCSSE and committee meetings), may have helped CSSS members build relationships that positioned them as "go-betweens" who fostered the use of research across boundaries. Our findings indicate the potential for these boundary practices to foster research-practice connections; nonetheless, as CSSS continues to engage in these activities, attention should be paid to how practitioners and researchers interact and whether and how these interactions facilitate a two-way RPP.

Another way in which the brokers in our study may have facilitated research use among CSSS members was via the use of boundary objects. All but one broker indicated using a National Academies consensus study report to inform their state's implementation of the *Framework for K-12 Science Education*, which suggests that these reports held significance and were applicable to both practitioners and researchers. As such, they have the potential to facilitate interactions across research-practice boundaries and to promote shared understanding related to transforming science education. Future work should attend to how these boundary objects are taken up in the above-described boundary practices, and whether and how brokers use these objects as they cross research-practice boundaries.

Though exploratory in nature, our findings resonate with conceptions of RPPs as involving "joint work at boundaries" (Penuel et al., 2015, p. 184), and suggest that partnership work can be facilitated by brokers' engagement in boundary practices and with shared boundary objects. Though there is still work to be done to ensure the development of a two-way partnership between practitioners and researchers, CSSS as a professional association has established routines that seem to be fostering research-practice boundary crossing and helping embed shared sources of research. In this way, CSSS has created a context for research use in the implementation of state science education policy.

Implications for Research and Practice

Our findings have several implications for research and practice; we discuss three here. First, our study expands research on RPPs in education, which tends to focus on schools and districts (Coburn et al., 2013; Coburn & Penuel, 2016), by examining research use at the state level. SEAs play a critical role in developing infrastructures that inform practice statewide (Farley-Ripple & Jones, 2015; Smarick & Squire, 2014), and several SEA leaders in our study served as brokers of research to inform their state's implementation of the *Framework for K-12 Science Education*. Our study thus motivates further examination of RPPs involving state leaders, and how these partnerships facilitate research use in statewide reform efforts.

Second, our findings indicate that professional associations in education may afford rich contexts for boundary crossing that enables research use. Prior research on professional associations indicates their relevance as a site for research-based ideas and resources that can transform practice around shared values and motivate collective action such as policy change (Gazley, 2014; Greenwood et al., 2002; Parada et al., 2010). Though our study begins to unpack the dynamics of research use in a professional association, more research is needed to understand the roles that brokers play in these processes, and whether and how these processes facilitate change to policy or practice.

Third, our study affirms the important roles that brokers can play in research use and identifies specific activities that may be useful in facilitating research use in professional associations in education. Such activities include association meetings and committees, as well as routines that develop shared tools, such as codesigned resources for professional learning. Given that professional associations are already an important source of research for educational leaders (Penuel et al., 2017), offering opportunities for leaders to engage in this type of joint work with researchers via their professional association may serve as a way to develop shared ideas across a particular field. These ideas can, in turn, lay the foundation for action.

Limitations and Future Research

Our study, like all research, has limitations. First, we examined boundary crossing among members of one professional association, which represents a threat to external validity. Our findings may thus not be generalizable to other professional associations or RPPs. CSSS is somewhat unique in its small size, organizational configuration, and communication structure; thus, similar research-practice boundary crossing may not be possible in other professional associations that are larger or more diffuse. Second, given that the majority of our data were collected at the CSSS annual meeting, our sample may have been biased in that it included those CSSS members who were generally more likely to participate in association activities. This kind of selection bias could have also stemmed from the relatively low response rate. Another concern with the low response rate is that the brokerage chains we were able to detect were biased by the missingness in the data. Similarly, that affiliate members were underrepresented in our sample may have underestimated their boundary crossing in CSSS.

Third, the way in which we asked questions on the survey did not allow us to explicitly examine the research exchanged across boundaries, or how particular sources of research were used in CSSS activities. Instead, we examined who participants turned to for research, as well as the research they used to inform their work. Future research directly examining what research and research-based ideas travel across boundaries, and investigating how and why it travels, could deepen understandings of boundary crossing and research use. Fourth, because our analysis focused on one moment in time, we were not able to capture how engagement in boundary practices influenced research brokering, or the ways in which brokers' roles shifted over time as they participated in joint work. Additional research exploring brokers' evolving roles in partnership work over time may be needed, as prior research demonstrates "the work of boundary spanners is different at the beginning of partnerships than when a partnership is mature" (Penuel, Coburn, & Gallagher, 2013, p. 252). Finally, research incorporating qualitative data is needed to better explore how engagement in boundary practices may afford opportunities for research-practice boundary crossing in professional associations, and how brokers navigate the research and practice communities. Such work is important for CSSS in particular, given the role the association plays in shaping statewide science education.

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