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The Common Core State Standards Initiative as an Innovation Network

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Abstract:	<p>This paper analyzes the Common Core State Standards initiative as an innovation network. Using narrative data and quantitative analysis of hypertext linkages on the WWW, we describe a network of about 3200 organizations that arose to scale up the CCSS and link them to aligned academic resources such as assessments, instructional materials, and professional development. By 2017, this network developed a "core-periphery" topology. The paper describes structures and processes at the core of the network that created strong pressures for construction of a coherent ecosystem of instruction for American education and processes at the periphery that worked against use of this system by most organizations in the network. The implications of these processes for educational reform are discussed.</p>

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The Common Core State Standards Initiative as an Innovation Network

Education researchers have increasingly analyzed the Common Core State Standards (CCSS) initiative as a case of policy change occurring within a large, national policy community composed of policy entrepreneurs, issue networks and advocacy coalitions, and networked governance arrangements that, in combination, facilitate public-private cooperation in the design, spread, and implementation of public policies. This view of the Common Core has its roots in “policy networks” research in political science and public policy studies (for reviews, see Börzel, 1997; Rhodes, 2006; Enroth, 2011) and entered education through research on the key roles that policy entrepreneurs, private foundations, advocacy groups, think tanks, and networked governance play in the education policy process (e.g., Mintrom & Vergari, 1998; Henig, 2008; Manna, 2010; Reckhow & Snyder, 2014). Using a policy networks approach, education researchers have produced a growing body of research on the rise, spread, and implementation of Common Core State Standards in American education. This research describes how a small group of policy entrepreneurs influenced the problem formulation and agenda setting stages of the CCSS initiative (e.g., Kornhaber, Griffith, & Tyler, 2014; Kornhaber et al., 2017); how these same policy entrepreneurs then mobilized resources from private foundations and the federal government to orchestrate uptake of the CCSS by states (McGroarty & Robbins, 2012; Layton, 2014; LaVenía, Cohen-Vogel, & Lang, 2014; Kornhaber, Barkauskas, & Griffith, 2016); how these policy entrepreneurs also worked with advocacy groups and think tanks to support and defend the CCSS initiative at various stages of the policy process (McDonnell & Weatherford, 2013a; McDonnell & Weatherford, 2013b; McDonnell & Weatherford, 2016; Kornhaber et al., 2017); and how state education agencies cooperated with non-governmental service providers as the CCSS initiative moved to the policy implementation stage (Russell et al., 2015; Hodge, Salloum, & Benko, 2016; Moffit et al., 2018; Salloum, Hodge, & Benko, 2020).

The goal of this paper is to extend policy networks research on the CCSS initiative by shifting the focus away from examining the CCSS as a case of policy change occurring within a large, national policy community and toward an examination of the CCSS as a case of instructional reform taking place within the K-12 school improvement industry more broadly conceived. As discussed in *Benchmarking for Success* (Jerald, 2008), the policy entrepreneurs who spearheaded the CCSS initiative wanted to do more than get common standards adopted as formal policy by states. The founders also wanted to link these new standards to “a wide range of tightly aligned instructional tools—from assessments to classroom curriculum materials” (Jerald, 2008: 26). For this reason, the CCSS initiative was more than just an effort to promote policy change within the U.S. federal system. It was also an effort to leverage widespread adoption of the CCSS by states to create what (in this paper) is called a “coherent” system of instruction, that is, a national ecosystem of instruction in which student assessments, instructional materials, and professional development services would be purposefully aligned to the CCSS and internally consistent with each other. The focus of this paper therefore turns from asking how a small band of policy entrepreneurs used social networks to accomplish a specific set of policy goals to studying how these same entrepreneurs tried to use social networks to build a coherent system of instruction within the larger K-12 school improvement industry.

To effect this analysis, we link research on policy networks to a body of research on innovation networks developed in organizations research. Like research on policy networks, research on innovation networks examines how social networks are initiated by entrepreneurs seeking to promote change, but in research on innovation networks, the focus is on how entrepreneurs use social networks to scale up complex, new technologies. To be sure, the scaling of new technologies often requires policy changes, and as a result, innovation networks often include actors from policy networks. However, a key difference between policy networks and innovation

networks is that innovation networks also include actors who operate at some remove from the policy-making process but are nevertheless important to the scaling of new technologies. In the case of the CCSS, these actors are located in what Rowan (2002) called the “school improvement industry,” that is, organizations that supply schools and their governing agencies with assessment products and services, instructional materials, professional development, and technical assistance. These are the organizations the policy entrepreneurs leading the CCSS initiative needed to coordinate in order to create a coherent ecosystem of instruction consisting of “textbooks, digital media, curricula, and assessments...aligned to [the CCSS]” (Jerald, 2008: 26).

This paper describes how organizations in the American school improvement industry came to be joined into a CCSS innovation network and further investigates whether the resulting structure of this CCSS innovation network led to the kind of coherent instructional ecosystem envisioned by the CCSS founders. As discussed in more detail below, our basic finding is that an inter-organizational network composed of thousands of organizations arose to support uptake and use of the Common Core State Standards. We find, however, that this network had a discernable core-periphery structure. The core of the network consisted of about 120 densely-connected organizations that included the CCSS policy entrepreneurs, the key funders and advocates they recruited into the initiative, and a small set of organizations the founders and funders “chartered” to create a coherent system of CCSS-aligned assessments, textbooks, and professional development. The CCSS network core also included a set of states that adopted and took vigorous steps to implement the CCSS as well as several other large, nationally prominent organizations that tied their missions to the Common Core. However, we find that the CCSS network also had a much larger peripheral component consisting of thousands of organizations and that these organizations developed a myriad of additional instructional, advocacy, and technical assistance resources to support CCSS implementation. Importantly, these peripheral organizations had only weak ties to

core actors in the CCSS network and to the CCSS-aligned instructional resources developed by core actors. This finding, we argue, helps clarify two vexing trends surfaced in research on local implementation of the CCSS, namely the tremendous proliferation of CCSS-related instructional resources available to practitioners and the difficulties practitioners have had fashioning these resources into a coherent (i.e. aligned and internally consistent) system of instructional resources to guide practice (McLaughlin, Glaab, & Carrasco, 2014; Russell et al., 2015; Hu et al., 2018; Moffit et al., 2018; Opfer et al., 2018).

The Theory of Innovation Networks

Background

Our work on the CCSS initiative as an *instructional* reform draws from research on innovation network by viewing instruction as a complex, multi-component technology consisting of academic standards, assessments, instructional materials, and professional development. Crucially, in the United States, these components of instruction are almost always produced *outside* of schools by organizations operating in what Rowan (2002) called the school improvement industry, and in the United States, a perennial problem has been a lack of alignment among these instructional components. It is well known, for example, that assessments, textbooks, and other instructional materials have been weakly aligned to each other and to state content standards, both in decades prior to release of the Common Core (Freeman et al., 1983; Webb, 1999; 2002) *and* after broad adoption of the CCSS by American states (Polikoff, 2015; Opfer et al., 2018; Polikoff and Dean, 2019).

Relevant Theory

A theoretical question addressed in this paper is whether network processes operating at the level of the U.S. school improvement industry affected the alignment of instructional components to one another and to the CCSS, and more importantly, whether there was anything a small group of

policy entrepreneurs did to effect such alignment. This is where research on innovation networks comes in. In organization theory, research on innovation networks examines how inter-organizational networks in different industries coordinate the actions of multiple, related manufacturers engaged in developing and spreading new technical systems (for reviews, see Dhanaraj & Parkhe, 2006; Malerba & Vonortas, 2009). The key takeaway from this literature is that network coordination processes can work to align multiple components of a technical system to each other and thereby promote coherence in technical design. A classic example occurred in the electronics industry, where coordination within a large innovation network produced “plug-and-play” compatibility among the components of personal computing systems (Den Hartigh et al., 2016). In this paper, we examine industry-level coordination processes within the CCSS innovation network, asking if (and how) network processes affected alignment of instructional components to one another and the CCSS.

Key Ideas

To address this question, we examine whether the CCSS innovation network developed along the lines identified in previous research on innovation networks. That research describes: (a) how innovation networks are founded; (b) how they expand; (c) how expansionary processes lead to development of a core-periphery network structure; and (d) the consequences of this core-periphery structure for the alignment of various components of an innovative technical system.

Network Founding. Research shows that innovation networks typically emerge as a result of “orchestration” (Dhanaraj & Parkhe, 2006). Here, one (or a few) hub organization(s) create intellectual property, which they seek to exploit for profit or technological advancement. Because hub organizations cannot achieve these goals alone, however, they typically recruit allies, and therein lies the origins of innovation networks. Early allies typically include venture funders (who provide initial funding for innovation scale-up), advocates (who work to legitimize an innovation in the face

of competition), producers (of the parts and processes necessary for production and implementation of an innovation), and early adopters (willing to try out the innovation in practice).

In theory, early orchestration sets the stage for coordinated action among organizations in an innovation network. For example, research finds that hub organizations often ally with familiar partners in order to assure that network members share similar cognitive frames at the outset and that such early alliances also stabilize network membership moving forward (Jones, Hesterly, & Borgatti, 1997). However, since hub organizations cannot always rely just on familiar partners to scale up an innovation, innovation networks also often come to include *unfamiliar* partners as well. As this occurs, additional steps are taken to promote coherence in innovation design, including use of formal controls (such as memoranda of understanding, grants, contracts) and/or the screening and inspection of new entrants for compliance. These formal coordinating processes also coordinate organizational action across the emerging network.

Network Expansion. Not every innovation network survives these founding stages (Callon, 1984), but networks that do often expand. By definition, expansion involves: (a) the addition of new organizations into a network; and (b) the formation of additional ties among organizations already in the network. New organizations enter an innovation network in two ways: first, as existing network members establish “out-of-network” ties, usually to gain innovation-relevant resources like information, funds, products, social support, and second, as organizations outside the initial network voluntarily join in when the network’s focal innovation gains in legitimacy, creates new market opportunities, or includes activities relevant to outside organizations’ goals (Dhanaraj & Parkhe, 2006). Network expansion can also be defined as an increasing number of ties among existing network members (Lescovec, Kleinberg, & Faloutsos, 2007). In real-world networks, this kind of expansion typically occurs through a process of preferential attachment in which organizations that

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3 already have many ties in a network establish a disproportionate percentage of new ties over time
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5 (Powell, White, Koput, & Owen-Smith, 2005).
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8 Network Structure. A third observation from research is that during expansion, innovation
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10 networks tend to develop a “core-periphery” structure (Borgatti & Everett, 1999; Dhanaraj &
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12 Parkhe, 2006; Csermely et al., 2013; Rombach et al., 2014; Kudic, Ehrenfeld, & Pusch, 2015). With
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14 preferential attachment, organizations in the initially-orchestrated part of the network develop dense
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16 ties to one another and with other prominent organizations that provide additional financial,
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18 informational, social, or technical resources relevant to the network (cf. Kudic et al., 2015). This
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20 creates a network core, that is, a set of organizations that are both densely inter-connected to one
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22 another and highly central within the expanding network.
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26 At the same time, expansion generates a network periphery, that is, a set of organizations
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28 with very few links to the core (Kudic et al., 2015). Research describes two plausible models of
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30 expansion at the periphery. In one model, networks expand outward like a forest fire, that is, by
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32 shooting embers out from the main fire to widely separated regions of a forest (Leskovec et al.,
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34 2009). In forest-fire expansion, a periphery develops because core organizations reach out to
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36 organizations that other core organizations do not reach out to, perhaps because core organizations
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38 have specialized functions within the network and require specialized partners or because core
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40 organizations have different familiar partners. As this occurs, many organizations enter the network
41
42 only weakly connected to most core actors. A complementary process occurs when outside
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44 organizations voluntarily join into the network but form ties with only one or a few core
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46 organizations. This will occur if new entrants’ agendas only partially overlap with those of core
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48 actors or because only one or a few organizations in the core have resources relevant to outsiders’
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50 agendas (Kudic et al., 2015). The main point is that either (or both) of these expansionary processes
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3 produces a large periphery in an innovation network, that is, many organizations with few ties to
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5 core actors.
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8 Consequences of Network Structure. A final idea from research is that a core-periphery structure
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10 affects how members of an innovation network coordinate their actions, which in turn affects
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12 coherence of the technical system being scaled up at the network core. The basic idea here is that
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14 inter-organizational ties within a network function like the loose and tight “couplings” discussed by
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16 Weick (1976). As organizations in the network core develop dense ties, they become more
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18 responsive to one another since dense ties increase communication, facilitate social control, and
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20 build consensus, creating coherence-producing actions that enhance resource compatibility among
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22 organizations (Uzzi, 1997). Conversely, organizations at the periphery of the network have fewer
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24 network ties and thus greater discretion over their innovation-related actions. Some analysts see
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26 discretion at the periphery as a net positive for continuous improvement of the new technical system
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28 being scaled up by the network. On this view, the densely connected organizations at the core of
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30 the network maintain a *fixed* version of the technical system, while the loosely-coupled organizations
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32 at the periphery propel innovation (e.g., Dhanaraj & Parkhe, 2006). However, other analysts view
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34 loose coupling at the periphery as a form of “chronic multiplicity” that degrades the coherence of
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36 the technical system being scaled up by core organizations (cf. Law & Singleton, 2014). Multiplicity
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38 occurs because the weak connections of peripheral organizations to the network core allow for
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40 many possible enactments of the technical system being scaled up, not all of which are the same—or
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42 even “coherent” in the sense of being coordinated through careful network orchestration.
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48 Research Questions

49 Analytic Goals of the Study

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52 In this paper, we use these key findings to formulate an “ideal type” model of the Common
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54 Core State Standards initiative as an innovation network. We then present a case study of the CCSS
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initiative involving what Lopreato and Alston (1970) call an “ideal-real” comparison. In this approach, the case analysis we present focuses on the provisional hypothesis that the CCSS initiative is, indeed, an empirical instantiation of the idealized form of innovation network just described. Importantly, however, this provisional hypothesis is not evaluated through causal analysis. Instead, an “ideal-real” comparison is a form of case classification in which the ideal type upon which the analysis is focused specifies a set of attributes one should expect to observe *if* the CCSS initiative is, in fact, a case of the hypothesized ideal type, and the research questions are descriptive in nature, evaluating whether or not the observed case manifests these characteristics (Becker, 1940).

Importantly, “ideal-real” comparisons contribute to both the ideographic and nomothetic aims of social science (e.g., Becker, 1940; Blumer, 1954; Lopreato and Alston, 1970; Hendricks and Breckinridge Peters, 1973; Weinert, 1996). With respect to ideographic aims, an ideal-real comparisons can improve a field’s “theory of a case.” In this study, for example, the goal is to extend the current view of the CCSS initiative as a type of policy network by further viewing the CCSS as a type of broader innovation network. This conceptual shift, if justified by descriptive evidence, will produce additional insights into the purposes of the CCSS initiative, the organizations involved in the initiative, and the consequences of the initiative. At the same time, our ideal-real comparison has generalizing (i.e., nomothetic) aims. For example, if the CCSS innovation network looks and functions like the idealized type of innovation network described in prior research, we have generalized a specific type of innovation network to a new case (the CCSS).

Specific Research Questions

The specific research questions to be examined in this paper are thus dictated by the features of the ideal type to which the CCSS initiative is being compared. In essence, we start with an idealized description of an innovation network, specifying that such a network: (a) will be initially orchestrated by entrepreneurs interested in scaling up a new “technology”; (b) who recruit close allies such as

1 funders, advocates, related producers, and early adopters to launch a scaling process; (c) which, if
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3 successful, leads to an inter-organizational network that expands beyond this initially orchestrated
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5 group in such a way as to produce (d) an inter-organizational network with a core-periphery
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7 structure; where (e) dense inter-organizational relationships at the core of the network reinforce a
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9 coherent version of the technology being scaled up; and (f) where loose coupling of organizations at
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11 the periphery of the network undermines coherence. Given this “ideal type,” the specific research
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13 questions for this study are as follows:
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19 *Questions about network founding and orchestration:* If the CCSS initiative was functioning as an
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21 innovation network, we should find evidence that the policy entrepreneurs who orchestrated the
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23 initiative enrolled advocates, funders, and early implements to support scaling up of an instructional
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25 ecosystem consisting of aligned standards, instructional materials, assessments, and professional
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27 development. To verify this assumption, we need to look at the kinds of organizations the policy
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29 entrepreneurs initially recruited into the CCSS network. Is there evidence that the CCSS founders
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31 recruited key advocates, funders, and early implementers into the CCSS network, and is there
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33 evidence that these partners were also trying to develop a coherent ecosystem of instruction?
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38 *Questions about network expansion:* If the CCSS initiative was functioning as an innovation
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40 network, we should also find that the early efforts of the CCS founders and initial partners led to
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42 network expansion (as described in our “ideal type” innovation network). To address this question
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44 we need evidence on the size and scope of the CCSS innovation network. In particular, how many
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46 and what kinds of organizations were in the CCSS network?
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49 *Questions about network structure:* If the CCSS network was indeed large (as the ideal type
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51 suggests), did the network manifest the kind of core-periphery structure described by our “ideal
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53 type”? In particular, what evidence is there that the CCSS network included a core of densely inter-
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connected organizations? And, what evidence is there that there was a large peripheral component of organizations only loosely coupled to the network core?

Questions about coherence of the CCSS instructional system being scaled: Finally, if the CCSS network did evolve into a core-periphery structure (as the ideal type suggests), did this structure have consequences for the coherence of the instructional system being scaled up at the core? In particular, what evidence do we have that dense ties among core organizations reinforced the system of CCSS-aligned instructional components being developed by the CCSS founders? Further, were peripheral organizations loosely connected to these “chartered” instructional resources, as the idealized model of an innovation network suggests?

Research Process

To examine these questions, we collected a variety of data (described below), then combined these data through a process of colligation in order to develop a narrative account about the CCSS initiative as an innovation network. As defined by Morgan (2017:89) colligation is a “way a scientist ... brings together...a set of similar elements framed under some overall guiding conception, or categorization schema.” Colligation was first described as a scientific method by Whewell (1847), came to be recognized in the 1960’s as a way of constructing historical narratives (for a review, see Cebik, 1969); and entered the field of sociology in the 1980’s as central method of concept construction and analysis (Abbott, 1984; Swedberg, 2017). In this paper, we use colligation for concept construction and analysis. That is, the central organizing scheme for our research is an idealized model of an innovation network (discussed at the outset of this paper), our interest is in addressing research questions about the correspondence of the CCSS initiative to this ideal type, and our research process “colligates” multiple pieces of data at appropriate places to produce a narrative account of the CCSS as an innovation network.

Initial Data Sources

The colligation process unfolded in stages. It began with: (1) a review of previous research and insider accounts about the CCSS initiative; (2) inspection of databases and documents describing legislative actions between 2009 and 2017 related to the CCSS initiative, including state legislation gathered from the National Conference on State Legislators database and federal legislation related to the Race to the Top (RTTT) initiative and related grants programs; (3) retrieval of data from the Foundation Directory's online database on philanthropic funding, including data on grants indexed by the keyword "Common Core"; (5) a systematic search of trade journals (*Business Wire*, *Education Week*, *Ed Surge*, *Ed Tech Update*, *PR Newswire*, and *Techcrunch*) using the key words "Common Core" to understand developments in the American school improvement industry over the period 2009-2017; (6) examination of available SEC and federal 990 filings of for- and not-for-profit organizations identified during the research process as engaged in CCSS-related actions; and (7) examination of the websites of organizations identified in the research process.

Using these data, we developed a provisional account of the CCSS initiative as an innovation network. The early data suggested that the same "policy entrepreneurs" identified in existing research on CCSS policy networks (i.e., Achieve, Inc., the Council of Chief State School Officers, and National Governors Association) copyrighted the CCSS as a piece of intellectual property, while the founders' arguments in *Benchmarking for Success* (Jerald, 2008) described how they intended to use widespread adoption of the CCSS to fundamentally alter the instructional ecosystem of American schooling. The early data further suggested that the CCSS policy entrepreneurs formed relationships with a set of venture funders (including the Gates Foundation and the U.S. Department of Education) and with prominent advocacy groups in American education, including prominent professional associations, advocacy groups, and think tanks (identified in Layton, 2014; Schneider, 2015; McDonnell and Weatherford, 2013). Databases on Gates Foundation and RTTT funding further suggested that all of these organizations coordinated their activities in a variety of ways to

scale up a “coherent” system of instruction consisting of new state assessment systems, aligned instructional materials, and aligned professional development.

Importantly, much of what we discovered in these early phases of research had already been discussed in existing policy networks research on the CCSS. However, as we saw it, existing research had colligated this information into a narrative about the CCSS initiative as a policy network composed of policy entrepreneurs, advocates, and policy adopters, *not* an innovation network that mobilized many additional organizations to construct an aligned ecosystem of instruction for American education. That struck us as problematic, however, because our extensive search of trade journals indicated that many organizations besides those identified in policy networks research were involved in the CCSS initiative, including many large and small businesses and not-for-profit organizations whose SEC and 1099 filings we examined. Having looked at these documents, we suspected that the CCSS initiative was more than just an effort by a small band of policy entrepreneurs to spur state adoption of the CCSS and was instead evolving into a sprawling educational reform initiative involving possibly thousands of diverse organizations. Importantly, our theoretical frame also suggested that as more and more organizations were joined into the CCSS initiative, the initially small inter-organizational network that the CCSS policy entrepreneurs had orchestrated might be evolving into a much larger inter-organizational network with a core-periphery structure. That larger structure, however, could not be described using the data we had gathered to that point. We therefore looked for an efficient way to discover which organizations in the American school improvement industry were involved in the CCSS initiative and to develop some quantitative methods for describing how these organizations were connected to other actors in the CCSS policy network.

Data on Hypertext Linkages on the World Wide Web

This led us to a body of research about mapping hypertext linkages among web pages on the World Wide Web and to related literature on the use of hypertext linkage data in formal network analyses. This body of work appealed to us for many reasons. To begin, in trying to discover the potentially large number of organizations involved in the CCSS initiative and map relationships among these organizations, our empirical problem was to uncover a “hidden” (i.e., not yet enumerated) social network by discovering nodes in that network and mapping linkages among those nodes. Because web sites are hosted by easily discoverable organizational entities, and because hypertext linkages are good public indicators of use by one of organization of another organization’s resources (like documents, videos, products, services, people, organizations, and more), we concluded that a “webmetric” analysis of the Common Core State Standards initiative was one (indirect) way of locating and mapping linkages among organizations in a potentially huge (but as yet undescribed) CCSS innovation network.

Method for Locating Nodes and Links. To implement this “webmetric” approach, we used the VOSON software hosted by Uberlink.com (Ackland, 2013). VOSON combines a web crawler with a Google analytics routine to identify hypertext links between web pages, which we aggregated to the website domain name (e.g. www.nctm.org). VOSON operates as follows. The software first crawls a set of user-specified web sites to locate up to 1000 out-bound links from that site and then uses a Google analytics function to gather up to 2500 in-bound links to that site. Thus, for any specified web site, VOSON identifies the organizations to which the specified site has out-bound links and the organizations from which that site receives in-bound links. VOSON can therefore be used to implement a form of “snowball” (or “link-tracing”) sampling that begins with a set of seed sites and identifies both outbound and in-bound links to these sites. In snowball sampling, one then expands this process to include all sites to which the initial seed sites are connected by (in- and out-bound links) to get another set of in- and out-bound links for additional sites, and then expands the

snowball sampling process to get another set of in- and out-bound links for these sites. Importantly, the more sites one samples, the more one enumerates nodes in an unknown network and identifies the in- and out-bound hypertext links among these sites. For this reason, web crawling and Google analytics routines are commonly used to locate nodes and links in online networks, although as we discuss below, the approach has known limitations (see Kurant, Markopoulou, & Thira, 2010; Ye, Lang, & Wu, 2010 for discussion).

In the current study, eight rounds of snowball sampling were conducted between May and October, 2017. The initial seed sites were the three organizations holding copyright to the CCSS (achieve.org; ccsso.org; nga.org) and the web site housing the CCSS (corestandards.org). In stages two and three of snowball sampling, all websites connected (by in- or out-bound links) to these websites were sampled. Successive stages sampled web sites with successively higher degree status until we reached stage eight, at which point all sites with at least 10 CCSS-focused (in- or out-bound) links to other organizations in the observed network were searched for in- and out-bound links, as were the home and academic standards pages of state departments of education not previously sampled. Overall, the websites of 272 distinct organizations were sampled for in- and out-bound links, yielding data on linkages among sampled organizations and thousands of other (un-sampled) organizations to which sampled organizations were connected.

Data Cleaning. Not all identified hypertext links among organizations identified during sampling were CCSS-related, however. Therefore, after each round of sampling, we pruned the data to assure that hypertext linkages in the database had direct relevance to the CCSS initiative. To do this, we employed a web scraping process that used the (case insensitive) search terms “common core” (excluding common core of data) or “CCSS” to label web pages in the data set as being CCSS-related or not. After each sampling stage, we pruned from the data any hypertext links that did not connect to or from a web page with these CCSS terms. This dropped from further analysis

organizations with no CCSS-related links to or from other organizations. During each sampling stage, we also inspected web site domain and subdomain names in an effort to restrict data only to organizations in what Rowan (2002) called the “school improvement industry.” For analytic purposes, eligible organizations were defined: (a) as any education governance agency operating above the local level and (b) any for- and not-for profit organization producing a product, service, information, or advocacy focused on the K-12 education system. The goal at this stage was to use domain and subdomain names to locate and prune from the data all social and commercial media sites offering opinions or news about the CCSS, as well as web sites of local schools and school districts, which we viewed as consumers of products and resources produced by the school improvement industry. Trimmed organizations were those with .K12 domain names or obvious school names in their subdomain (e.g., Eisenhower_High_School). We also tried to use domain and subdomain names to also trim out organizations whose main line of business was not K-12 education—including real estate, insurance, and technology firms as well as the main websites of institutions of higher education or their academic divisions. Here, subdomain names (like WilliamsRealty) gave some clues as to ineligibility. Using these procedures, we developed provisional data set of 8,105 organizations, all of which had at least one CCSS-focused hypertext link to another organization in the data set and whose domain or subdomain name did not clearly indicate ineligibility. However, additional hand inspection of a sample of these organizations’ websites revealed that trimming on the basis of domain and subdomain names still left our data set with organizations that we defined as ineligible for study. Therefore, in a final round of data cleaning, we hand-coded the remaining 8,105 organizations, screening first for eligibility (as defined above) and then applying codes developed inductively over successive stages to classify organizations into the “types” of organizations shown in Table 1. This final coding process produced a final data set of 3,236 organizations.

Table 1 about here

Coding Process. The reduction of cases from 8105 to 3236 involved successive steps. In a first coding step, we employed 189 individuals from the Amazon Mechanical Turk (AMT) crowdsourcing workforce to make coding decisions. Each organization in the initial data set was coded by at least two AMT workers. At this stage, AMT workers first examined the web site of a given organization and coded the organization operating that website as eligible or not for study based on the following instructions. A site was coded as *ineligible* by a coder if the organization operating the site was a K-12 school or district, college or university, personal blog, news organization, foreign organization, or if it had a broken URL and a site was coded as eligible if the organization running the website was judged to be in the field of K-12 education, where to be in this field, the organization had to have information on its web site indicating its main mission was serving K-12 schools, students, or their families by providing educational products, services, or advocacy relevant to K-12 education. Then, for any organization an AMT worker judged as eligible, the AMT worker was given our list of organizational types (with definitions) and instructed to code eligible sites into “types” using information on the focal site’s home page.

After completing this data cleaning step, we analyzed inter-rater agreement among AMT workers. General agreement among AMT workers about site eligibility was 81%, but this was driven by the high percentage of sites that both AMT workers agreed were *ineligible* for study as opposed exact agreement that a given site was eligible for study. Moreover, among sites that one or both AMT workers coded as eligible for study, rates of agreement about the type of organization operating the website was low, ranging from 37% to 6% depending on organizational type. As a result, we took additional steps to clean and code the data. Of the 8,105 organizations coded by

AMT workers, we kept existing codes for all sites coded by an author as eligible during the sampling stage (847 sites) and all sites where both AMT coders coded a site as eligible and agreed as to its organizational type (905 cases). We then dropped from further coding all sites where both AMT coders coded a site as ineligible and agreed about the reason for ineligibility (263 sites). Next, the authors resolved cases where AMT coders disagreed about case eligibility (2,574 sites), coding each site an author judged as eligible into the types shown in Table 1. Next, the authors resolved disagreements among AMT raters about organizational types that both AMT raters deemed as eligible, reconciling disagreements about type by: (a) applying the code most frequently chosen by the two AMT raters (where AMT workers coded multiple types); or (b) if this vote count method failed to produce a code, by hand reconciling disagreements via direct coding by an author. After these steps were completed, 3,236 (of the initial 8,105) organizations were coded as eligible for study. Most of the sites eliminated from analysis at this final stage were local schools and school districts (that had .com, .net, or .org domain names and/or ambiguous subdomain names). Of these 3,236 eligible sites, 847 were coded by the authors during sampling and had stable codes at all stages of data cleaning, 981 were hand coded by the authors as they resolved disagreements about site eligibility, and 1,408 sites were re-coded by the authors because AMT workers disagreed about organizational type or the vote count method failed to produce a code. In a post hoc analysis, we examined a sample of 681 web sites that were double-coded by the authors and found that the author's coding decisions about organizational type had 96% exact agreement.

Measurement and Sampling Error in the Data. The coded data on hypertext linkages are subject to two types of error. One type of error arises from rater disagreement about organizational eligibility and type. Given that there were 189 AMT workers and in light of extensive data cleaning, we view coding errors as a form of random measurement error that introduces little to no *systematic* bias into our analyses. However, a second type of error in the data *does* have the potential to introduce

systematic bias into our analyses. This is sampling error arising from our use of snowball sampling to identify web sites for analysis. We now discuss the systematic errors that snowball sampling might have produced in our analyses and the steps we took in light of this problem.

Heckathorn and Cameron (2017) discussed the conditions under which snowball sampling leads to biased estimates of node composition and degree distribution in social networks. One problem occurs because a convenience sample of seed sites is used to launch the sampling process. This can produce an un-representative sample of nodes and links if the number of initial seeds is small and if these seeds are located within closed and distinctive communities. Under these conditions, statistics about sample composition (such as the percentage of different types of organizations in our network data) can be inaccurate. A second problem occurs because snowball sampling always tends to disproportionately discover highly connected (i.e., high degree) sites at the earliest stages of sampling. In small samples, this will affect the accuracy of node-level statistics (such as the degree status of nodes in the network), and that is important in our case because data on average degree status and degree distribution are central to conclusions we are going to make about the extent to which the CCSS network developed into a core-periphery structure. A final problem is that our snowball sampling process gathered *complete* data on in-and out-links only for the 272 organizations we directly sampled (via crawling and use of Google analytics), meaning that we have incomplete (i.e., “missing”) data on at least some of the in- and out-links of organizations that we did not directly sample.

Notably, the first two problems can be addressed using best practices from the literature on snowball sampling. This literature shows that biases in sample-level estimates of node characteristics are greatly reduced when many seeds are used in snowball sampling (as was the case in our study) and when initial seeds yield in- and out-links spread across areas of the network in subsequent sampling (as was the case in our study, as shown in Appendix A). Under these conditions, both Gile

and Hancock (2010) and Ye, Lang, and Wu (2010) have shown that estimates of node composition (such as the percentages of organizations of a particular type in our sample) can fall within the confidence interval of estimates from probability samples, especially as sample size increases. Increased sample size can also help reduce bias in estimates of average degree status in an observed network. Indeed, Kurant, Markopoulou, and Thira (2010) showed that bias in degree distribution estimates decreases rapidly as sample size approaches 8% of the network population. This pattern was also observed in our data. After 8 rounds of snowball sampling, the degree status of the 272 organizations we directly sampled ranged from 254 to one, with a sharp skew toward lower degree sites. Therefore, our multiple rounds of snowball sampling clearly led to discovery of low degree sites, reducing bias in our estimates of average degree status in the observed network.

However, there was a remaining problem. As noted earlier, we gathered complete data on (in- and out-bound) links for just 272 of the 3,236 organizations in our data set. As a result, we have complete data on links only for these 272 sampled organizations. This complete data, it should be noted, gives us data on all of the (in- and out-bound) links that the 272 sampled organizations have to each other as well as complete data on these organization's (in- and out-bound) links to the remaining 2964 (un-sampled) organizations. However, we do *not* have complete counts of the (in or out-bound) links that un-sampled organizations might have to one another, nor do we have complete data on the links that un-sampled organizations might have to other organizations not included in our data. So, this missing data problem produces a potential downward bias in the degree statistics reported for un-sampled organizations in our data, which in turn might result in a biased estimate of the skew in our observed network's degree distribution.

Network researchers are divided about how to handle this missing data problem. Some researchers use statistical procedures to correct for bias, but this requires advanced knowledge of the real network (Kurant, Markopoulou, & Thira, 2010) or complete data on the degree status of

sampled sites (Heckathorn and Cameron, 2017). Lacking such information, we could not implement these approaches. In our case, we could also correct for bias by restricting the data analysis to just the 272 sampled sites (and, in so doing, only examine links among these sites). This would produce complete data on a well-defined “neighborhood” of the larger (but unknown) CCSS network and all statistics about this neighborhood (including that neighborhood’s degree distribution) would be unbiased. However, limiting the analysis in this way would prevent us from examining data on the 2,964 sites that were not sampled but were nevertheless known to be in the CCSS innovation network. For this reason, we decided to use the full data set (on sampled and un-sampled organizations), acknowledging that this produced an unknown amount of sampling error and potential bias into our analyses of degree distribution. Appendix B (online) presents a more detailed discussion of this problem, showing how the observed degree distribution estimated for the CCSS innovation network might differ using different samples. Appendix B also describes where in our presentation of results the reader should (or need not) be cognizant of possible sampling error.

Creation of Network Data. To conduct a formal network analysis of these data, we represented hypertext links in the data set as a square adjacency matrix of a network graph. The rows and columns of the matrix were the 3,236 organizations in the data and the cells were indicators of hypertext links between organizations. In most analyses, we report undirected links among these organizations (i.e., whether or not two organizations are linked, ignoring the direction or number of links between them). This vastly simplifies visual depiction of the CCSS network and subsequent quantitative analyses. However, we do report on directionality of links when we discuss network expansion, although in this case, we do not weight these links.

Analysis of Network Data. A formal network analysis of the data was implemented using the R statistical package *igraph* (R Core Team, 2007; Csardi & Nepusz, 2006), which we used to calculate network statistics and create a graphic representation of the data. The main analytic tool applied to

the data was a K-cores decomposition of the network graph. Here, the total graph was decomposed into subgraphs, where members of each subgraph maintained at least k links to other members of the total graph. K-cores are used in social network analysis to visualize network structure, to reveal the central actors in a network, and to interpret coordination processes in graphed networks (Khaouid et al., 2015). In the current study, we used a K-cores decomposition to identify core and periphery sectors of the observed CCSS network, defining the core of the network as organizations in the highest K-cores and the periphery of the network as organizations in lower K-cores (Rombach et al., 2013). The cut point for classification was determined by looking at the degree distribution in the observed data and classifying all organizations in K-cores 13 and above as core organizations and all organizations located in K-cores 12 and below into the periphery of the network. We also used the K-cores decomposition for visual representation of the network. Here, the data will be presented in a concentric circles layout, where the circles in the graph are K-cores. Finally, we used the K-cores decomposition to describe underlying coordinative processes operating within the CCSS network. Here, we report on the patterns of linkages that organizations in the core vs. periphery had to organizations chartered by the CCSS founders to produce CCSS-aligned instructional components.

Key Assumption. A key assumption in our analysis is that hypertext links have *sociological* significance. In particular, we assume that observed hypertext linkages measure flows of CCSS-related resources (like information, funds, social endorsements, products, and services) and that organizations with established hypertext linkages are making coordinated use of these resources. This accords with research showing that hypertext links are often formed when one organization points to information or resources on another organization's website, when hypertext links are used to signal joint memberships, contractual, or funding relationships among organizations, and/or when one organization uses a hypertext link to another organization to establish authority in a

domain (e.g., Ackland & Gibson, 2010; Thelwall, 2006). Interviews with key personnel in a small number of organizations confirmed this interpretation, as did inspection of numerous hypertext links in the data. As a result, we decided to analyze the hypertext linkages in our data using formal network analysis.

Findings

As discussed, we colligated the hypertext linkage data with other data to make an “ideal-real” comparison between observed features of the CCSS network and the ideal type of innovation network described in prior research.

The Network as a Whole

A useful place to begin this ideal-real comparison is with Figure 1. This is a concentric circles layout of the *entire* CCSS innovation network. In the layout, each ring is a K-core of the observed hypertext linkage network, where the outermost rings are organizations at the lowest K cores (i.e., organizations with fewer links in the observed network) and the innermost rings are organizations at successively higher K cores (i.e., those having more links in the observed network). Overall, the figure depicts 3262 organizations and 7539 undirected links among them. Table 2 shows how these 3262 organizations were distributed across K-cores of the network, as well as the average number of undirected links the average organization at each K-core had: (a) to any organization in the network; (b) to organizations in the core of the network; and (c) to organizations in the periphery of the network. In combination with the concentric circles layout, this table shows the kind of skewed degree distribution typically present in a core-periphery network structure. To see this skew in graphic form, refer back to Figure 1, where one can easily see the dense connections among organizations in the inner rings (i.e., the “core” of the network) and the less dense connections of organizations in the outer rings (or “periphery”) the network core. Thus, Figure 1 and Table 2 are

consistent with the ideal type's expectation that the CCSS network will display a core-periphery structure.

Figure 1 about here

Table 2 about here

Network Founding, Initial Orchestration, and Creation of an Aligned Instructional System

We now turn to how the CCSS network shown in Figure 1 was founded and whether it was constructed to create a system of instructional resources aligned to the CCSS. To do this we link the data shown in an online appendix (Table C1) to findings from our early investigations of various (non-network) data. Table C1 is a listing of *all* the organizations found in the core of the observed CCSS innovation network, along with various node statistics for these organizations. We now discuss how the data in Table C1 are consistent with other data we collected on the founding and aims of the CCSS innovation network.

Network Founding. Existing accounts of the CCSS initiative (e.g., McGroarty & Robbins, 2012; Layton, 2014; Schneider, 2015; Kornhaber, Barkauskas, & Griffith, 2016) provide a rich description of how the CCSS innovation network was launched, and notably, many aspects of those accounts are consistent with the data in Table C1. To begin, previous accounts show that three organizations with longstanding ties to one another—the NGA, CCSSO, and Achieve, Inc.—launched the CCSS initiative in 2008. As expected, these organizations are located in the core of the network and have high centrality in the observed network (as shown in Table C1). Moreover, existing accounts show that early in their work, the founding organizations reached out to two initial funders, the Gates Foundation and the U.S. Department of Education (e.g., McGroarty & Robbins, 2012; Layton, 2014; Schneider, 2015). These two organizations are also in the core of the CCSS network (as

shown in Table C1). Data from the Foundation Directory showed that the Gates Foundation provided the CCSS founding organizations with the venture funds they needed to write the CCSS. These same data showed that the Gates Foundation also funded several advocacy and membership organizations to develop a persuasive cognitive frame for the initiative (see also McDonnell and Weatherford, 2013a). Importantly, all of the organizations identified in the Foundation Directory data and by McDonnell and Weatherford (2013a) are shown in the “orchestrated network” section of Table C1. In addition, previous accounts have shown that the U.S. Department of Education (ED) was recruited as an additional early funder of the CCSS initiative, initial contacts being made between the Gates Foundation and the incoming Obama administration’s “transition” team—contacts that eventually led to the appointment of several Gates employees to key positions in ED (Layton, 2014; Schneider, 2015). Importantly, Table C1 shows that ED was also in the core of the observed CCSS network.

Initial Orchestration. The early efforts of the founders to recruit venture funders led to “orchestrated” expansion of the CCSS network. In particular, the Gates Foundation’s funding to write the Common Core brought new organizations such as Student Achievement Partners and ETS into the innovation network (Layton, 2014), and both these organizations are in the core of the CCSS network (as shown in Table C1). Then, ED’s Race to the Top (RTTT) initiative fueled additional network expansion. One stream of RTTT funding provided monetary incentives for states to adopt challenging academic standards, leading to additional inter-organizational coordination within the emerging network, first as states signed memoranda of understanding with the NGA to adopt the CCSS (LaVenía, Cohen-Vogel, & Lang, 2014), then as the NGA and CCSSO, working with the Gates Foundation, funded a selected group of states to prepare RTTT grant applications, and then as states recruited partners to join their RTTT applications (Russell, et al.,

2015). In the end, these actions were associated with a very rapid adoption of the CCSS by states, bringing the various state education agencies shown in Table C1 into the CCSS network.

Creation of an Aligned Instructional System. Importantly, the policy entrepreneurs spearheading the CCSS initiative wanted to do *more* than get states to adopt the CCSS. In 2009, RTTT funding also was used to create the two new state assessment consortia (which are both in the core of the network as shown in Table C1). These organizations were deliberately chartered by the network founders and funders to develop state accountability tests tightly aligned to the CCSS. Then, in 2010, with the CCSS initiative still in its infancy, the NGA, CCSSO, and Achieve hosted forums to discuss alignment of curriculum materials to the CCSS (Watt, 2016), and shortly thereafter, the Gates Foundation funded several organizations to help align textbooks and professional development to the CCSS. In one line of funding, startup funds were provided for what ultimately became EdReports (Watt, 2016), an organization that was expected to function like Consumer Reports to rate the alignment of major textbook series to the CCSS. Another line of funding (from the Gates Foundation and ED) went to development of the CCSS-aligned curriculum materials known as *EngageNY*. Importantly, both of these organizations are in the core of the CCSS network (as shown in Table C1). Beyond this, the Gates Foundation provided grants to two other organizations it hoped would create and spread professional development resources aligned to the CCSS—Student Achievement Partners and the Teaching Channel (both of which are in the core of the observed network as shown in Table C1). And finally, around this time, ED took steps to align federal technical assistance to the CCSS by funding several comprehensive assistance centers to assist states in the areas of standards and assessments (as described on the U.S. Department of Education website at <https://www2.ed.gov/programs/newccp/index.html>). Several of these organizations are also in the CCSS network core (as shown in Table C1, where they are labeled as technical assistance providers).

Existing accounts of the CCSS initiative further describe a number of ways that organizations in this initially-orchestrated network coordinated their activities to build coherence in this evolving *instructional* reform effort. First, people working in the offices of the founders and early funders had longstanding ties to one another (Layton, 2014; Snyder, 2015) and personnel circulated among these organizations (Layton, 2014). The advocacy groups recruited into the network were also subject to network controls, including not only the constraints of grant funding from the Gates Foundation, but also frequent communications among themselves (McDonnell & Weatherford, 2013a). These grants, contracts, and circulation of personnel all worked to align the actions of these organizations to one another and to the organizations chartered by the network to provide instructional materials and professional development for the CCSS (Layton, 2014). Importantly, these narrative accounts of the density of interconnections among the founders, funders, advocates, and instructional resource providers are consistent with the hypertext linkage data shown in Figure 1. For example, in the network graph shown in Figure 1, organizations in the orchestrated core are denoted as black dots, making it easy for the reader to see their location within the overall CCSS network. Figure 1 shows in graphical form just how dense the connections were among members of this orchestrated network. Thus, multiple pieces of primary, secondary, and archival data suggest that: (a) the CCSS innovation network was initiated by a set of entrepreneurs holding copyright to a piece of intellectual property; (b) that these founders recruited early funders, a set of advocates, and a set of instructional resource providers, creating an orchestrated core of the CCSS network; and (c) that all members of this initially-orchestrated network developed dense ties to one another.

Further Network Expansion

But this is *not* the end of the story. As the data in Figure 1 show, the CCSS innovation network was much larger than the orchestrated network just discussed. Indeed, as the data in Table 2 showed, we identified more than 3000 organizations as being in the CCSS network, and as the data

in Table C1 showed, the core of this large network included more than the just the 24 organizations identified as being in the “orchestrated” component of this network. Thus, we now turn to a discussion of network expansion at both the core and periphery of the CCSS network.

Expansion at the Network Core. One reason the CCSS innovation network expanded was the rapid adoption of the CCSS by 43 states. As discussed in existing research, state adoption of the CCSS was incentivized by the RTTT program (Lavenia, Cohen-Vogel, & Lang, 2014) and further supported by the NGA, CCSSO and the Gates Foundation. This process no doubt encouraged CCSS network expansion, leading all 50 state education agencies and the District of Columbia (DC) to appear in our hypertext linkage data. However, not *all* states—or even all CCSS adopting states—ended up in the core of the CCSS innovation network. Instead, as Table C1 shows, only 23 state education agencies and the DC school system were in the core of the observed CCSS network. In an analysis (not shown here), we examined how state education agencies located in the core of the CCSS network differed from those located in the periphery. That analysis showed that state education agencies in the CCSS network core did not differ from those in the periphery on measures of total student enrollment, instructional spending per student, or whether a state received an RTTT award. Instead, states in the network core were more likely than states at the periphery to be closer (in network distance) to the CCSS founders and to have a greater percentage of web pages on their web site making reference to the Common Core. These findings are consistent with the theoretical idea that core states were more likely than peripheral states to be “familiar” to the founders and highly active in developing CCSS-related resources.

Table C1 also shows that additions to the core of the CCSS network included more than just states. In addition to 24 states, the three founders, and the 21 members of the “orchestrated” network, the network core included 22 other membership organizations, 18 other advocacy organizations, 11 publishers of textbooks or other kinds of instructional materials, 14 other

professional development/technical assistance providers, and a small number of other types of organizations. In exploratory analyses not shown here, we once again compared various characteristics of these core organizations to organizations in the periphery. These analyses found that compared to organizations in the network periphery, organizations in the network core were closer in network distance to the founders, had more web pages on their web sites, and had a higher percentage of web pages referencing the CCSS. Again, we see these findings as consistent with the theoretical idea that organizations familiar to the founders, more strongly committed to developing CCSS-related resources, and having more capacity for outreach (as evidenced by total number of web pages) ended up being in the core of the CCSS innovation network.

Evidence gathered from the web sites of core organizations (as well as our search of other documents and databases) provided further insight into why these core organizations became involved in the CCSS initiative. Most of the advocacy organizations shown in Table C1 had been working on issues of education reform for decades prior to the CCSS and had board members who were well-connected to the founders and/or personnel in other organizations in the orchestrated network. So, these advocacy organizations (and their personnel) were well-placed actors in American education. Similarly, most of the membership organizations shown in Table C1 were prominent in American education. All were large organizations and represented the most prominent occupations and governance roles in education, including school administrators, school boards, and subject matter teachers. Nine technical assistance providers (shown in Table C1) were also in the network core, about half of which were federal contractors (whose government contracts required them to provide CCSS-related services and products). The remaining technical assistance and professional development providers (shown in Table C1) were private or not-for-profit organizations positioning themselves to gain market share by aligning their work to the CCSS (as indicated by web site inspection and federal 990 and SEC filings). A “market motive” probably also

accounts for the presence of the three large publishers appearing (in Table C1) in the core of the network. This motive was apparent in these organizations' SEC filings, product acquisitions, and (in the case of Pearson) involvement in the PARCC assessment consortium. A similar market motive accounts for the presence of several lesser-known instructional materials providers in the network core (as shown in Table C1), although these organizations also could have achieved core status through search engine optimization (i.e., deliberate linking to prominent organizations). Note finally that two standards-setting organizations (Advance CTE and the Next Generation Science Standards) appear in the core of the CCSS network despite the fact that these organizations were primarily concerned with standards *other than* the CCSS. Their presence in the network core is largely due to the fact that they were working with Achieve, Inc. and, in effect, borrowing on this organization's legitimacy and expertise for a purpose outside the narrow realm of scaling up the CCSS.

"Forest Fire" Links from Core to Periphery. The data in Table C1 show another way the CCSS network expanded—through what we earlier called "forest fire" expansion. Hodge, Salloum, and Benko (2016) presented data on this process in an earlier study showing that state education agencies reached out to various instructional resource providers as they implemented the CCSS. However, that study found that states did not rely solely on the "orchestrated" instructional resources of the CCSS network but also worked with many other providers, most of which had ties to just one or a few states. We know from preliminary research that other core members of the CCSS network also built up these kinds of distinctive network connections. The two assessment consortia, for example, operated in different states with mostly different subcontractors and thus developed consortium-specific resource networks, while core advocacy and membership groups also worked with distinctive partners. The extent of this "forest fire" expansion therefore partially explains the formation of a network periphery—a group of organizations with ties to just a few members of the CCSS network core.

To get a sense of just how important this “forest-fire” process was to network expansion, one can look at the sixth column of Table C1, which shows the number of out-links each core organization made to organizations in the periphery. That column shows that virtually all core organizations established out-bound links to organizations in the periphery. Calculations from the data further show that core organizations established about 2500 out-bound links to the periphery. Importantly, however, most core organizations reached out to a distinctive set of organizations in the periphery. Indeed, in an analysis not shown here, we found that only about 20% of organizations in the periphery received more than one link from a core organization, suggesting that core organizations tended to develop distinctive resource networks.

Mobilization of Peripheral Organizations into the Network. While the findings to this point suggest that development of distinctive resource sets by core actors was central to development of a CCSS network periphery, other data show just how prevalent this process was from the perspective of peripheral organizations. In analyses not shown here, we sorted peripheral organizations into four types: organizations in the CCSS network only because a core organization initiated a link to them (n=2175), organizations connected to the CCSS network only because they initiated a link to a core organization (n=336), organizations connected to the CCSS network because they received a link from a core organization *and* sent a link to a core organization (n= 315), and organizations that neither sent a link to nor received a link from a core organization (n=294). Thus, nearly 70% of all organizations in the periphery were connected to the network core by out-bound links from the core, suggesting that “forest-fire” mobilization was a major process through which organizations came into the CCSS network.

Compositional Differences in Core vs. Periphery. An interesting question is whether (and how) organizations in the periphery of the observed CCSS network differed from core organizations. One possibility could be that different types of organizations (as defined in Table 1) were located in

the core and periphery regions of the CCSS network. Table C2 (online) presents relevant data on this point and is summarized here. As noted in online Appendix D, this analysis is sensitive to sampling error, and as a result, the findings in Table C2 should be treated as provisional. Bearing that in mind, the left hand panel of Table C2 shows the percentage of each type of organization classified into the core and periphery; the right hand panel shows the share that each type of organization represented in the different regions. Looking at the two panels shows that states and membership organizations made up a greater share of the observed CCSS network core while instructional materials providers made up a greater share of the observed CCSS network periphery. This likely reflects two things. First, the orchestration strategy pursued by the CCSS founders had as its initial goals to get states to adopt the CCSS and to use key membership groups to build support for the CCSS initiative within the education profession. Thus, it is not surprising to find states and membership organizations are likely in the network core. By contrast, the comparatively larger percentage of instructional materials providers in the periphery of the CCSS network reflects the founders' reliance on just two main organizations to achieve alignment of instructional materials to the CCSS (EdReports and *EngageNY*) and the fact that the founders did not "charter" other organizations to provide instructional materials for the CCSS.

In other analyses, we examined whether organizations of the same type located in the core or periphery differed in certain respects. On this point, we found that holding constant type of organization, core organizations were closer in network distance to the CCSS initiative's founders, had a greater number of web pages on their web sites, and had a higher percentage of their web pages referencing the CCSS than did peripheral organizations. Thus, holding constant organizational type, organizations in the CCSS network periphery were more socially distant from the founders, lacked capacity to make network connections, and were not as centrally concerned with the CCSS as organizations in the network core.

A Closer Look at Organizations in the Periphery of the CCSS Network

We now summarize in more detail the specific numbers and types of organizations located at the periphery of the CCSS network (see Appendix D for some supporting discussion of these data).

Advocacy Organizations. There were 660 advocacy organizations in the periphery of the observed CCSS network. This is consistent with the idea that advocacy plays an important role in innovation, but it also shows that in a decentralized education system (like the United States), core organizations tended to reach out to organizations operating below the national level for advocacy resources. For example, inspection of web sites showed that many advocacy organizations in the network periphery had a long history of advocating for standards-based reform, either as it intersected with literacy and mathematics instruction or as it affected disadvantaged and minority students, students in special education, or with various trends in instructional practice. But where organizations in the periphery differed from organizations in the core was that peripheral organizations oriented their standards-supporting activities to state and local levels, reflecting the decentralization of American education.

Not all advocacy organizations in the CCSS periphery operated regionally or locally, however. However, national advocacy organizations in the periphery (unlike advocacy organizations in the core) tended to represent more specialized populations within the highly differentiated structure of student services and programs in American education. For example, numerous organizations in the periphery advocated for pupils with very specific legal statuses in American education, while others advocated for types of schooling not specifically encompassed by the CCSS, such as Pre-K education, after-school programming, home schooling, and charter schooling. Other peripheral organizations advocated for educational programming not explicitly covered by the Common Core, such as arts education, career-technical education, nutrition education, parent education, science education, and socio-emotional learning. So, the large number of advocacy organizations in the

periphery also seems to have arisen through core organizations' efforts to mobilize more specialized interests into the CCSS innovation network.

Membership Organizations. The network periphery also included 532 membership organizations, and once again, web site inspection showed that these organizations differed from core membership organizations in certain respects. Whereas the membership organizations in the core of the CCSS network included the most important national associations of teachers, subject matter specialists, educational administrators, boards of education, parents, states, big city school districts, and business leaders, membership organizations in the periphery of the CCSS network included additional constituencies, including national, regional, and state organizations representing virtually *all* of the numerous smaller occupational specialties in the field of education, as well as membership organizations that functioned as alternatives to the NEA and AFT, organizations representing school districts located in rural areas, and various membership associations for the general public. Here, then, the large number of membership organizations in the periphery seems to have resulted as core organizations mobilized additional occupations and constituencies into the CCSS network.

Publishers. The network periphery also included 49 (of 52) publishers in our data base. Three of the top publishers in American education were in the network core (Pearson, Scholastic, and Discovery), but three others were not (Cengage, Houghton-Mifflin-Harcourt, and McGraw Hill). Also in the periphery were several smaller publishers of textbooks/programs used in subjects and grades covered by the Common Core and whose materials were reviewed by EdReports.org, including American Reading, Amplify, Benchmark Education, Big Ideas, Carnegie Learning, Curriculum Associates, Jump Math, Kendall Hunt, Learn Zillion, Open Up, and Wiley. But many publishers whose materials were *not* reviewed by EdReports.org were also in the CCSS network periphery, including mainstream publishers like MacMillan, Jossey-Bass, Prentice Hall, Random House, and Routledge, as well as lesser known publishers of education materials like Nelson, Wilson

Language, and Gander. Data from SEC and 1099 filings show that many of these publishers saw market opportunities in the CCSS, and the data on forest fire expansion implies that many core organizations saw these publishers as having relevant resources for the CCSS.

Instructional Materials Providers. The periphery also included 654 providers of “instructional materials” other than textbooks. Web site inspection showed that this group provided schools and teachers with: (a) lesson plans and classroom activities; (b) worksheets and exercises; (c) collections of readings, primary source materials, visual displays, and activities kits; (d) educational applications and games; (e) digital programs for personalized learning and response-to-intervention; and (f) organizations that arranged for volunteers and experts to conduct lesson activities at schools or in off-campus settings. The instructional resources provided by these organizations focused not only on reading and mathematics, but also on many other academic and extracurricular subjects not explicitly a part of the Common Core. Importantly, almost all of the instructional resources these organizations provided were free and easily accessed, none were subject to review by EdReports, and many have been used widely and regularly by teachers (Opfer et al., 2016). Website inspection suggested that these resources were provided mostly by small organizations operating in what Baumol (1982) called “contestable” markets (where government regulation is minimal, the resources needed to produce and market a product are easily acquired, and there is little need to expend “sunk” costs prior to market entry). Since contestable markets facilitate entrepreneurial activity (Baumol, 1982), market conditions in the school improvement industry probably account (in large part) for why so many different kinds of instructional materials were available for mobilization into the CCSS initiative.

Professional Development/Technical Assistance Providers. The CCSS network periphery further included 120 technical assistance (TA) providers and 363 professional development (PD) providers. Web site inspection showed that TA providers included national and university-based organizations

that had been (or are now) a part of the federal labs and centers programs, as well as numerous intermediate education agencies in states, and many regional or state organizations providing state-specific technical assistance. These organizations provided a range of technical assistance, including assistance in assessment, planning, policy analysis, program development, program implementation support, program evaluation, and resource acquisition. Interestingly, PD providers were even more numerous than TA providers. Web site inspection showed that some PD providers had multiple trainers, partnered with multiple districts, and operated at a national scale. But far more were “mom-and-pop” providers with one or two employees. Moreover, most PD providers were generalists whose CCSS-related work was only a part of the organization’s overall mission.

Other Organizations in the Periphery. The periphery also included 66 organizations providing formative and summative assessments and related services, including prominent assessment providers (e.g., ACT, Data Recognition, DIBELS, the GED, Metametrics, Measured Progress, Northwest Evaluation Associates, Renaissance Learning, Riverside Publishing) and smaller providers (e.g., Assistments, Formative, iTEP, Quantiles, Scientific Learning, Star Quality Exams, Word ID Assessments). As Molnar (2017) pointed out, the market for formative assessments was expanding very rapidly in the post-CCSS era, so the presence of assessment firms in the CCSS network is not surprising, especially given that the RTTT assessment consortia did not provide such assessments. Also in the network periphery were 159 organizations providing management products and services, including learning management systems and software used for other management functions (like budgeting, personnel, and attendance). Given the proliferation of instructional materials, the presence of organizations providing learning management systems is unsurprising. Also in the CCSS network periphery were 112 organizations providing out-of-school tutoring services, as well as 39 organizations providing mentoring, scholarship, or college placement services. Their presence in the CCSS network reflects the importance of “college and career” readiness to the CCSS initiative.

Findings on Coherence

These data on the size and diversity of the CCSS network periphery lead to a final research question--whether formation and expansion of the CCSS network had a bearing on the CCSS founder's aim of building a *coherent* system of instruction in American education. Recall that the CCSS founders were attempting to orchestrate an instructional system consisting of a selected set of advocates working with a small set of "chartered" instructional resource providers, where dense interconnections among organizations would align organizational actions to promote coherence in instructional design. However, the data presented to this point also shown that the CCSS network expanded via a forest fire-like process to include thousands of organizations in addition to the orchestrated core, with the vast majority of peripheral organizations being only loosely coupled to the network core via one (or a few) links to that core. A key research question for this paper, then, is whether this loose coupling of peripheral to core organizations ended up working against the founders' aim of developing a coherent instructional system and instead resulted in resource multiplication across the CCSS network and fragmentation of the CCSS founders' orchestrated technical system.

Table 3 presents some descriptive data on this issue. The premise behind the table is that organizations that have links to one another are responsive to one another and thus harmonizing their actions (Weick, 1976; Uzzi, 1997). To assess responsiveness, Table 3 reports the percentages of organizations in the core *vs.* periphery that had at least one (in- or out-) link to the founders' chartered instructional resources, including: (a) the CCSS (i.e., corestandards.org); (b) one or both of the RTTT assessment consortia (i.e., Smarter Balanced or PARCC); (c) one or both of the organizations chartered to align instructional materials to the CCSS (i.e., EdReports and/or EngageNY); and (d) one or both of the organizations chartered to align PD to the CCSS (Student Achievement Partners or the Teaching Channel). The table also reports an average "coherence

score” for organizations in different regions of the observed CCSS network, where this is simply a count of the number of connections listed above. The maximum score on the index is four, indicating that a focal organization is simultaneously using all four kinds resources in the CCSS founders’ orchestrated instructional system; scores of 1, 2, or 3 are indicators of technical fragmentation (i.e., organizations are using only pieces of the founders’ orchestrated technical system), and a score of zero indicates *no* connections to the network’s chartered instructional resources.

Table 3 about here

Table 3 reveals an underlying pattern of coordination within the CCSS network with respect to development of an “aligned” instructional ecosystem. In each column of the table, it is apparent that organizations in the core of the CCSS network were far more likely than organizations in the periphery of the network to be linked to the network’s orchestrated instructional resources, a finding that is expected given the core-periphery structure of the network and the location of the chartered resource providers in the network core. In particular: (a) 53% of core organizations vs. just 3 % of organizations in the periphery were linked to the CCSS (i.e., corestandards.org); (b) 51% of organizations in the core of the CCSS network vs. 5% of organizations in the periphery were linked to one or both of the RTT assessment consortia; (c) 38% of organizations in the core of the CCSS network vs. 3% of organizations in the periphery were linked to one or both of the network’s orchestrated instructional materials resources; and (d) 66% of organizations in the core of the CCSS network vs 6% of organizations in periphery were linked to one or both of the network’s orchestrated PD resources. Core organizations also had a higher average coherence score than did peripheral organizations (2.07 vs. just .20). Thus, as expected by the theory of innovation networks, organizations at the core of the observed CCSS network were more oriented than organizations at

the periphery to the founders’ aligned instructional resources and used more aligned resources in their work. This finding therefore summarizes how expansion of the CCSS innovation network and its development into a core-periphery structure contributed not just to resource “multiplicity” within the network (as illustrated by the sheer number and diversity of resource providers in the periphery), but also to resource “fragmentation” (as illustrated by the limited number of direct ties organizations in the periphery had to the network’s orchestrated system of instruction).

Discussion

In summary, this paper presented a narrative account of the Common Core State Standards initiative as an innovation network. Consistent with the theoretical idea that innovation networks are typically launched by hub organizations, we found that among the central actors in the CCSS innovation network were: (a) the CCSS copyright holders; (b) the early funders and advocates recruited to help write the standards and promote adoption; and (c) a small set of organizations chartered by the founders and funders to develop assessment, curriculum, and professional development resources aligned to the CCSS. However, our quantitative analysis also identified a large number of additional organizations in this CCSS network and showed that the CCSS network was characterized by a core-periphery structure. In the paper, we presented descriptive data on how this core-periphery structure was related to the founders’ intention to scale up a coherent system of instruction centered on a small set of “chartered” providers of CCSS-aligned assessments, curriculum and instructional materials, and professional development. The quantitative data showed that 116 organizations of national prominence were located at the core of the observed CCSS network and that these organizations had dense ties with each other, with the network’s founders, and with the founders’ orchestrated instructional resources. But the quantitative data also showed that a process of forest fire -like expansion brought thousands of additional organizations into the CCSS network, bringing a multiplicity of additional advocacy and instructional resources to the

CCSS network. Moreover, the data showed that most additional resource providers were only weakly tied to the CCSS network core or to the core's orchestrated system of instructional resources. This loose coupling, we argued, led both to resource multiplication across the CCSS innovation network and to fragmented use of the founders' orchestrated system of instructional resources by most organizations in the network.

Importantly, the results presented here are consistent with (and also extend) policy networks research on the CCSS initiative. In particular, our analyses suggest that policy networks researchers have (to date) done an excellent job describing various neighborhoods within the larger CCSS innovation network. Indeed, the colligated data presented in this paper are consistent with previous "policy networks" research describing: (a) the key role that policy entrepreneurs played in the CCSS innovation network (e.g., Kornhaber et al., 2016); (b) the key role that advocacy groups played in supporting the Common Core (McDonnell & Weatherford, 2013); and (c) the key role that state implementation networks played in the CCSS initiative (Russell et al, 2015; Hodge, Salloum, & Benko, 2016). What has been missing from "policy networks" research, however, has been any strong sense of the embeddedness of these network neighborhoods within a much larger, industrywide CCSS innovation network as well as a concrete description of that innovation network. Our analysis, by contrast, viewed the policy networks described in previous research as fully embedded within a larger—industrywide—CCSS network and showed how the core-periphery structure of that larger network affected the technical (not just policy) aims of the founders.

Clearly, more research is needed to understand how this larger innovation network functioned and with what consequences for the founders' instructional reform goals. One need is to link the network data just presented to other data on outcomes of the CCSS initiative. As an example, the theory of innovation networks predicts that dense interconnections among organizations at the core of the CCSS innovation network will help stabilize the coherent system of

instruction developed by the CCSS founders. In the paper, we addressed this issue using data on
hypertext linkages among organizations, but the stabilization problem could also be examined within
a hypothesis testing framework that used other than hypertext linkage data. As one example, we
conducted some very preliminary logistic regression analyses to see if a given state's location within
the core or periphery of the observed CCSS innovation network predicted that state's persistent
adoption of the CCSS and/or persistent membership in one of the two RTTT assessment consortia.
After controlling for state size, instructional funding, and student composition, we found that states
in the core of the observed CCSS network in 2017 were more likely in 2018 to still have the CCSS as
their *official* state standards and were also more likely to be current members of the PARCC or
Smarter Balanced consortia (compared to states in the periphery of the CCSS network). While these
findings require more sophisticated replication, they do suggest that an organization's location in the
core of the CCSS innovation network is associated with stable use of the founders' chartered
instructional resources.

Other work on the CCSS innovation network should be qualitative. We conducted only a
few interviews with key informants in organizations in the observed CCSS network, and as a result,
we know little (beyond what we learned from our initial investigative work) about the specific ways
organizations at the core or periphery thought about the alignment of peripheral resources to the
founders' chartered instructional resources. It could be that people working in organizations at both
the core and the periphery thought that peripheral organizations' resources *were* tightly aligned to the
CCSS and to its central instructional resources. But the actual motivations of core and periphery
organizations for linking, and how core and peripheral organizations interpreted their joint
alignment to the CCSS founders' coherent system of instruction, are issues that require more
research.

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3 Finally, there is a need to better understand how the CCSS innovation network might evolve
4 and change over time. Because the historical web cannot be crawled, we could not reconstruct how
5 the CCSS innovation network looked in its early stages or how it evolved to the structure we
6 described. Going forward, however, it would be possible to replicate our methods and study how
7 the CCSS network is evolving. What might happen, for example, when this innovation network
8 loses central actors (like PARCC and Achieve) or experiences increasing de-adoption of the CCSS
9 (the intellectual property) around which the network is formed, or as markets for key technical
10 components evolve? These are all questions worth exploring in future research on CCSS initiative
11 as an innovation network.
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Table 1: Types of Organizations Coded During Data Collection

Type	Definition
Accreditation	Organizations that engage in accreditation of schools or programs.
Advocacy	Organizations whose stated mission is Advocacy for a particular position or policy.
Federal/State Agency	Agencies of the federal or a state government that are not affiliated with the U.S. Department of Education or a state education agency.
Foundation	Any organization that identifies itself as a foundation and has an endowment that it distributes to other entities or uses in support of its operating activities. Organizations calling itself a 501(c)3 foundation that solicit funds for Advocacy was coded as an Advocacy organization.
Founder	The three organizations holding copyright to the Common Core State Standards (the National Governors Association, the Council of Chief State School Officers, and Achieve, Inc.).
Instructional Materials Provider	Organizations that provide materials/services that are intended for use in classrooms instruction and that are <u>not</u> core textbooks, programs, or trade books. The category includes organizations that provide supplemental instructional programs/materials, intervention programs used in classrooms, blended learning products, worksheets/exercises/tests, lesson plans, as well as organizations that arrange for persons to come into a school to provide special purpose lessons.
Legal	Organizations that provide education-related legal services to schools, school systems, or families.
Management	Organizations that provide learning management or other management software (i.e., in areas such as attendance, personnel, grading/marking, finance) or organizations that provide non-instructional (and non-legal) management consulting to schools.
Membership	Organizations that collect membership dues and represent a group of people or organizations.
Professional Development	Organizations whose primary mission is providing professional learning experiences and/or training for school personnel
Publisher	Organization that is a print or digital publisher of trade books, textbooks, or digital texts that span grade levels and are sold for use as a core “program” or “series” in math, reading, science, etc.
Research	Organizations that engage in research (without Advocacy) or organizations intending to service such organizations through provision of data, statistical support, etc.
State Education Agency	The department of education within a state.
Standards	Organizations that have developed a set of standards for teachers, schools and school systems, or students as their primary mission
Student Support	Organizations (other than tutoring agencies) whose main mission is to provide support for students in the form of services, scholarships, mentorships, contests, etc.
Technical Assistance	Organizations that provide multifaceted assistance to states or LEAS, including federal assistance centers, intermediate service providers within states, and other private or not-for-profit organizations that provide similar services.
Testing	Organizations that publish tests and provide assessment services for state assessment systems, other summative assessments, or formative assessments.
Tutoring	Organizations whose primary product is direct (online or in-person) tutoring, plus providers of software/materials intended for use in tutoring, after school, or home settings.

Table 2: Degree Statistics by K Core of the CCSS Network

K Core	Number of Cases	Average Degree	Average Number of Links to Core	Average Number of Links to Periphery
1	2147	1.00	.87	.13
2	429	2.05	1.74	.31
3	195	3.09	2.48	.61
4	98	4.27	3.28	.99
5	67	5.27	4.25	1.01
6	46	7.54	5.04	2.50
7	38	9.00	5.61	3.39
8	18	10.50	6.22	4.28
9	24	13.00	7.67	5.33
10	23	15.26	8.09	7.17
11	20	19.00	9.50	9.50
12	15	21.73	11.33	10.40
13	13	24.31	13.08	11.23
14	11	27.18	15.18	12.00
15	25	39.40	18.36	21.04
16	4	39.75	20.00	19.75
17	63	100.14	34.95	65.19

Table 3: Percent of Core and Periphery Organizations Linked to CCSS Network's Chartered Resource Providers and Average Coherence Scores

Region of Network	% Connected to Core Standards	% Connected to RTTT Assessment Consortium	% Connected to Orchestrated Instructional Materials	% Connected to Orchestrated PD Resources	Average Coherence Score
Core	53%	51%	38%	66%	2.07
Periphery	5%	5%	3%	6%	.20

Appendix A: Sensitivity of Findings to Choice of Initial Seeds

This appendix discusses how our specific choice of initial seeds for snowball sampling of the CCSS network might have affected our findings about the specific nodes and links in that network. As discussed in the main body of the paper, snowball sampling is not probability sampling, and for this reason, researchers have rightly expressed concerns that snowball sampling often produces *un*representative samples of the nodes and links in a real (but “hidden”) network. As it turns out, snowball sampling is especially prone to this problem under two conditions discussed by Gile and Hancock (2010), Ye, Lang, and Wu (2010), and Heckathorn and Cameron (2017). These are: (a) when the real network being sampled is highly clustered by homiphily; and (b) when the initial seeds in snowball sampling are located in just one (or a few) of these distinctive clusters. To the extent that these conditions are present, initial seeds will uncover links to organizations located only in highly self-contained neighborhoods of the larger network, which will, in turn, lead these neighborhoods to be *over*represented in a sample and other neighborhoods *under*represented. Conversely, research also shows that this bias can be substantially reduced: (a) when initial seeds produce links across all neighborhoods of a clustered network and (b) when sampling is conducted over multiple waves, especially if the network being sampled has a sufficiently small amount of clustering.

We now discuss whether these bias-reducing conditions were present in the observed CCSS network. This discussion is based on an analysis of the modularity (i.e., clustering) of the observed CCSS network using the hierarchical community detection algorithm developed by Clauset, Newman, and Moore (2004) as implemented in the R statistical package iGraph (version 1.2.6). Use of this modularity optimizing algorithm identified 18 different communities within the observed CCSS network, producing an overall (network) modularity index of .48. As Newman (2006) observed, modularity index scores for large networks typically range from .3 to .7, so the observed CCSS network had a statistically meaningful degree of clustering. Moreover, the modularity data further showed that the initial seeds (Achieve.org, Core Standards.org, CCSSO.org, and NGA.org) for snowball sampling were located in just 3 of these 18 different communities. However, additional inspection of the network modularity data suggests why this did not lead to a great deal of initial seed bias in our resulting sample. In particular, the modularity analysis showed that the core of the CCSS network was not characterized by strong clustering (modularity = .17), and as a result, after the very first wave of sampling, our initial seed sites produced links to sites in *all other* sub-communities in the overall network. So, successive waves of sampling were drilling down into all network communities, not just the communities in which the initial seed sites were located. In fact, additional inspection of the data suggested that the observed network would not be markedly different had we arbitrarily chosen a different set of seeds, as long as those seeds were located in the core of the CCSS network and we conducted eight waves of sampling (as we did in the current study). Importantly, these findings do *not* mean that snowball sampling of the CCSS network using any set of seeds would produce the same sample of CCSS nodes and links. For example, had we chosen sites located at the periphery of the CCSS network as initial seeds, our observed network would almost certainly have ended up looking very different from the one we described in the paper, in large part because network clustering in the CCSS network resulted from forest fire expansion where core organizations created out-links to relatively unique sets of peripheral organizations. Under these conditions, peripheral organizations are less “productive” seeds in the sense that they are less likely than core sites to produce connections to organizations in all network neighborhoods.

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Appendix B: Sensitivity of Findings to Missing Data

In Appendix A, we made the case that the productive set of seeds used in our snowball sampling process allowed us to achieve a sample of nodes located in all neighborhoods of the “hidden” CCSS network. However, as discussed in the main body of the paper, the snowball sampling procedure we used also produced incomplete data. Recall, in particular, that we did not crawl *all* sites in the sample, and as a result, we did not have complete data on in- and out-links for all nodes in the network. In this appendix, we discuss how this pattern of missing data affects our analysis.

As discussed in the main body of this paper, we conducted eight waves of sampling, over which time we collected *complete* data on in- and out-links for 272 organizations (hereafter called “crawled” sites) but collected *incomplete* data on the in- and out-links of the remaining 2964 (“un-crawled”) organizations in the data set. Importantly, this produced a very particular pattern of missing data on linkages in the overall network data. For so-called “crawled” sites, we have complete data on in- and out-links, including complete data on links to other crawled sites and complete data on links to un-crawled sites. However, for *un-crawled* sites, we have complete data only on (in- and out-links) to crawled sites, and we have potentially incomplete data on the (in- and out-) links of un-crawled sites to: (a) other un-crawled sites; and (b) any sites that might be in the network but are not in our data set.

How Missing Data Affects Degree Distribution. Importantly, this failure to get complete data on the in- and out-links of un-crawled sites has the potential to downwardly bias the reported degree status for un-crawled sites, which in turn produces an artificially high skew toward low degree sites in the final sample. Therefore, we conducted a set of analyses (reported in this appendix) to give us a better sense of just how much the presence of missing data affected our estimated degree distribution. These analyses were built up from three potential strategies that researchers have discussed for analyzing data on degree distribution in the face of missing data of the sort present in our sample. These strategies include: (a) analyzing all cases in the data, even if there is missing data; (b) analyzing data only for crawled sites, which have complete data; and (c) analyzing data only for crawled sites, and within that data set, including in the data only links to other crawled sites.

The results of using these different strategies on our CCSS network data are presented here as three histograms of the degree distribution in a given sample (along with an implied distribution curve, assumed to be exponential in form.) Figure B1 is the degree distribution for all cases in the data. Figure B2 is the degree distribution for crawled sites only (counting links of these sites to both crawled and un-crawled sites). This figure is presented to see what a network degree distribution might look like if we restricted our analysis only to crawled sites, for which we have complete data on degree status. Figure B3 is the degree distribution for crawled sites counting only links to other crawled sites. This is an unbiased estimate of the degree distribution for a particular neighborhood of the larger network in which we are really interested.

Note that each figure shows a skew in the degree distribution, with more sites having lower degree status than higher degree status, although the distributions do differ in amount of skew. To quantify this difference, we fit exponential distributions to each graph. The gamma parameter of the best fitting exponential distribution is 0.22 for the first graph, 0.03 for the second, and 0.05 for the third. Q-Q plots (not presented here) show that the degree distribution shown in Figure B1 has a very good fit to the exponential distribution, whereas the distributions shown in Figures B2 and B3 had some departures from expectations at lower degree. Overall, the figures and analyses show that sampling and crawling procedures *do* affect estimates of degree

distribution; but the figures also show that there is a skew in degree distribution (with more lower degree than higher degree sites) no matter what sample is used. This suggests the degree distribution in the “real” CCSS innovation network is almost certainly skewed along the lines discussed in the paper, that is, the “real” network almost certainly includes a greater proportion of low degree than high degree sites. However, the extent to which the real network has a degree distribution that approximates Figure 1 is uncertain.

Figures B1, B2, B3 about here

How Missing Data Affects Data Reported in Tables. The reader is cautioned that the distinctive pattern of missing data also can affect other statistics reported in this paper, although as we shall see, not all statistics. In particular, all organizations in K-cores 13 and above in the observed CCSS network were crawled, and these were also the organizations we labeled as being in the core of the observed CCSS network. Knowing this, we now discuss how incomplete data on the degree status of un-crawled organizations did and did not affect statistics reported in various tables presented in this paper:

In Table 2 (in the main body of the paper), we report the average degree status of organizations at different K Cores. In this table, the degree statistics for K-cores 13 and above are accurate (since all organizations in these K-cores were crawled), whereas the degree statistics for K-cores 12 and below have the potential to be under-estimated, since the vast majority of organizations in these K-cores were not crawled.

In Table C1 (in Appendix C), we report node statistics for all organizations in the core region of our observed network. Since all organizations in the core were crawled, the columns showing in- and out-links (to both core and periphery) are accurate. However, the rankings of core organizations on various centrality measures shown in the table could be affected by missing data on the links of un-crawled organizations, especially if the crawling of additional organizations in subsequent rounds of sampling uncovered many sites with high enough degree status to enter the core of the network. We investigated this possibility at several steps in our sampling process. First, after each round of crawling, we looked at how the degree status of organizations and K cores of the network changed. Here, we found that the number of K-cores in the data was stable after several waves of sampling and that, as sampling went on, fewer and fewer sites were discovered with high enough degree status to be in the core, until, by the penultimate round, only 1 of the 18 sites crawled was elevated to core status. Then, after the final round of crawling, we took a random sample of 42 un-crawled sites in the data. Here, we found that the degree status of these newly crawled organizations did increase on average, but of the 42 sites newly crawled, only one moved to core network status. From this, we concluded that organizations’ general positions within the core and periphery of the CCSS network were mostly accurate.

Table C2 (in Appendix C) reports data on types of organizations located in the core and periphery of the observed network. Since we do not have a random (or weighted probability) sample of nodes in the CCSS network, we did not compute standard errors for these estimates or conduct formal statistical tests of differences in organizational composition of core and periphery regions of the observed CCSS network. The analyses are thus exploratory in nature. However, we do have some confidence in the percentages reported in the table. Recall that in the body of the paper, we cited Gile and Hancock (2010) and Ye, Lang, and Wu (2010) who reported that estimates of network composition based on snowball sampling often fall within the confidence interval of estimates from probability samples, especially as sample size increases and when

network clustering is weak enough to allow initial seeds to uncover links to all network neighborhoods. We discuss this issue further in online Appendix D.

Table 3 (in the main body of the paper) shows the percentage of organizations in the core and periphery of the observed CCSS network that were linked to founders' chartered instructional resources. Since the websites of these chartered resource providers were crawled, we have complete data on all organizations to which these organizations are connected by both in- and out-links. Thus, the data in the table are *not* affected by the fact that most organizations in the periphery were not crawled. Any links of peripheral organizations to the chartered resource providers would have been captured when the web sites of these chartered providers were sampled.

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Figure B1: Degree Distribution for All Sites in Data

Figure B2: Degree Distribution for Crawled Sites Only (Links to All Sites)

Figure B3: Degree Distribution for Crawled Sites Only (Links to Crawled Sites)

Appendix C:
Table C1: Node Statistics for Organizations in CCSS Network Core (N = 116)

Name	Category	Links to Core		Links to Periphery		Rank on Eigenvector Centrality	Rank on Betweenness Centrality
		In	Out	In	Out		
Founders and Key Intellectual Property							
CCSS	Founder	37	24	32	137	1	4
Council of Chief State School Officers	Founder	27	25	7	31	12	32
Achieve Inc.	Founder	4	28	0	17	45	67
National Governors Association	Founder	12	4	1	1	165	226
Orchestrated Network							
Gates Foundation	Foundation	11	8	3	9	73	158
U.S. Education Department	Federal Agency	8	22	0	5	50	73
National Association of Elementary School Principals	Membership	28	22	25	147	6	6
Alliance for Excellent Education	Advocacy	7	43	3	41	13	38
Learning First Alliance	Advocacy	18	4	4	9	61	99
America's Promise	Advocacy	4	14	0	8	79	131
Council of Great City Schools	Membership	21	14	26	66	23	17
National Council of English Teachers	Membership	12	26	5	60	16	24
ASCD	Membership	3	53	0	32	8	28
National Education Association	Membership	3	35	1	23	24	39
National Association of State Boards of Education	Membership	28	6	19	4	36	56
American Federation of Teachers	Membership	0	31	0	15	39	61
Education Commission of the States	Membership	7	17	2	17	63	77
State Education Technology Directors Association	Membership	5	10	2	16	96	86
Massachusetts Business Alliance for Education	Membership	15	1	7	2	110	120
Smarter Balanced Assessment Consortium	Testing	22	20	27	78	9	16
PARCC Assessment Consortium	Testing	37	9	56	38	11	23
Engage NY	Instructional Materials	27	8	26	55	22	22
EdReports	Standards	16	6	8	21	62	60
Teaching Channel	Professional Development	42	7	68	37	10	13
Student Achievement Partners	Technical Assistance	10	42	2	93	5	14
Other Core Organizations							
Arts Education Partnership	Advocacy	3	7	41	43	13	38
Competency Works	Advocacy	9	25	32	15	17	47
Thomas B. Fordham Institute	Advocacy	31	31	9	3	32	35
EdSource	Advocacy	20	24	34	9	35	33
Colorin Colorado	Advocacy	19	17	72	14	37	20
Collaborative for Student Success	Advocacy	4	18	9	4	61	99
Common Sense	Advocacy	1	3	41	15	67	54
Students at the Center	Advocacy	18	18	1	0	75	81
LD Online	Advocacy	0	4	8	14	79	131

Table C1 (cont.): Node Statistics for Organizations in CCSS Network Core

Name	Category	Links to Core		Links to Periphery		Rank on Eigenvector Centrality	Rank on Betweenness Centrality
		In	Out	In	Out		
The Whole Child	Advocacy	12	11	21	6	80	55
Digital Promise	Advocacy	18	13	1	2	93	90
Change the Equation, Inc.	Advocacy	6	10	7	5	102	105
America's Promise Alliance	Advocacy	9	14	1	1	117	142
American Youth Policy Forum	Advocacy	2	14	0	0	122	173
Project Tomorrow	Advocacy	5	7	11	6	123	112
Albert Shanker Institute	Advocacy	0	5	6	8	130	156
National Center for Education Statistics	Federal	2	13	8	20	40	71
Rodel Foundation	Foundation	18	20	3	0	72	84
Computing Technology for Math Excellence	Instructional Materials	40	36	198	17	2	1
Reading Rockets	Instructional Materials	28	28	54	7	20	19
Internet4Classrooms	Instructional Materials	1	1	85	26	42	18
Teachers First	Instructional Materials	1	4	15	22	55	97
Teach Hub	Instructional Materials	5	9	38	11	64	31
Classroom 2.0	Instructional Materials	7	10	5	4	98	123
teAchnology	Instructional Materials	39	13	2	0	104	42
Blackboard	Management	2	10	12	23	34	46
CommPartners	Management	2	11	0	2	107	140
National Council Teachers of Mathematics	Membership	10	22	116	37	4	9
TESOL International Association	Membership	0	3	32	53	8	28
Advance CTE	Membership	5	12	60	26	16	24
American Association of Colleges of Teacher Education	Membership	4	12	132	22	31	7
National Network of State Teachers of the Year	Membership	1	1	49	29	38	30
National School Boards Association	Membership	0	0	15	31	39	61
American Association of School Administrators	Membership	0	2	21	26	41	41
Technology Information Center for Administrative Leadership	Membership	4	25	2	0	49	116
National Science Teachers Association	Membership	0	4	21	19	60	53
National Association of Secondary School Principals	Membership	1	1	15	17	70	93
National Association for Gifted Children	Membership	0	2	10	15	83	118
School Leadership 2.0	Membership	2	5	16	10	96	86
Association of American Educators	Membership	15	14	15	3	97	63
Southern Regional Education Board	Membership	7	15	2	1	110	120
National Association of School Psychologists	Membership	0	2	5	11	114	141
Georgia Partnership for Excellence in Education	Membership	3	12	2	4	132	188
Buck Institute for Education	Professional Development	5	16	12	7	56	65
Solution Tree	Professional Development	2	6	46	19	58	40
Education World	Professional Development	2	5	44	16	69	36
TeachThought	Professional Development	2	12	3	1	100	152
The Teachers Academy	Professional Development	4	13	1	0	131	114

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Table C1 (cont.): Node Statistics for Organizations in CCSS Network Core							
Name	Category	Links to Core		Links to Periphery		Rank on Eigenvector Centrality	Rank on Betweenness Centrality
		In	Out	In	Out		
Scholastic	Publisher	2	15	11	18	29	43
Pearson	Publisher	1	5	5	22	47	68
Sage	Publisher	0	3	7	25	53	64
Discovery Education	Publisher	4	11	17	9	71	70
California Department of Education	State Education Agency	12	14	196	37	3	2
Rhode Island Department of Education	State Education Agency	1	23	19	16	18	45
Hawaii Department of Education	State Education Agency	16	15	127	17	27	12
Nevada Department of Education	State Education Agency	3	5	130	24	28	8
Maine Department of Education	State Education Agency	30	25	39	6	30	25
Arizona Department of Education	State Education Agency	4	4	54	21	46	29
Delaware Department of Education	State Education Agency	10	13	72	12	48	26
New York State Education Department	State Education Agency	4	4	50	19	54	34
Washington Office of Superintendent of Public Instruction	State Education Agency	13	15	24	5	57	37
New Hampshire Department of Education	State Education Agency	1	3	11	20	59	88
Arkansas Department of Education	State Education Agency	2	13	6	10	65	113
Indiana Department of Education	State Education Agency	1	0	15	18	68	92
Massachusetts Department of Education	State Education Agency	1	2	12	15	76	104
New Mexico State Department of Education	State Education Agency	3	11	14	6	78	78
Alabama Department of Education	State Education Agency	5	14	11	4	81	82
Colorado State Department of Education	State Education Agency	1	11	8	4	84	103
Idaho State Department of Education	State Education Agency	2	8	14	5	85	76
Connecticut State Department of Education	State Education Agency	1	5	12	13	86	135
Pennsylvania Department of Education	State Education Agency	6	12	15	5	87	66
New Jersey Department of Education	State Education Agency	0	4	6	10	90	119
Washington, DC Public Schools	State Education Agency	1	4	7	11	91	139
Louisiana Department of Education	State Education Agency	2	12	10	4	92	95
Maryland Department of Education	State Education Agency	3	11	9	2	95	106
West Virginia Department of Education	State Education Agency	0	6	0	7	127	195
Next Generation Science Standards	Standards	51	34	40	6	19	15
National Board for Professional Teaching Standards	Standards	0	9	14	8	94	89
American Institutes for Research	Technical Assistance	10	16	17	25	25	48
WestEd	Technical Assistance	2	10	93	42	5	14
Positive Behavioral Intervention and Supports	Technical Assistance	18	16	6	0	88	59
South Central Comprehensive Center	Technical Assistance	9	31	5	1	43	69
Northwest Comprehensive Center	Technical Assistance	3	24	0	0	66	159
Education First	Technical Assistance	8	19	4	2	77	126
Core Education LLC	Technical Assistance	0	14	10	5	108	129
Center for Standards and Assessment Implementation	Technical Assistance	3	7	20	6	112	87
GovTech	Technical Assistance	1	12	2	1	119	247
Helping with Math	Tutoring	33	18	5	0	74	50

Table C2: Composition of Core and Periphery Regions of the CCSS Network

Type of Organization	N	Percent of Each Type Located In a Region		Percentage of a Region Composed of Each Type	
		% of Type Located in Periphery	% of Type Located in Core	Percent of Periphery Composed of Type	Percent of Core Composed of Type
Advocacy	660	97%	3%	20%	18%
Instructional Materials	654	99%	1%	21%	7%
Membership	532	96%	4%	16%	26%
Professional Development	363	98%	2%	11%	5%
Management	159	99%	1%	5%	2%
Foundation	144	99%	1%	5%	2%
Technical Assistance	114	95%	5%	4%	5%
Tutoring	111	99%	1%	4%	1%
Testing	66	97%	3%	2%	2%
Research	54	96%	4%	2%	2%
Publisher	52	94%	6%	2%	3%
State Education Agency	51	53%	47%	1%	21%
Standards	44	96%	4%	1%	2%
Federal/State Agency	40	93%	7%	1%	3%
Student Support	39	100%	0%	1%	0%
Legal Services	8	100%	0%	.3%	0%
Accreditation	4	100%	0%	.1%	0%
Founder	4	0%	100%	0%	3%

Appendix D: Plausibility of Estimates of Network Size and Composition

In the body of this paper, we cautioned readers about the accuracy of the data in Table C2, which provided estimates of sample composition, that is, the percentages of different types of organizations within the observed CCSS network. At issue in this table is that we used snowball sampling to locate organizations in the CCSS network. It is well known that snowball sampling can produce inaccurate statistics on network composition, even in cases where there is minimal initial seed bias. Moreover, because of missing data, we were unable to use the kinds of sampling weights discussed in Heckathorn and Cameron (2017) to estimate the proportions of different types of organizations represented in the observed CCSS network.

In light of this issue, we now discuss the plausibility of the network composition estimates provided in Table C2. As discussed in the main body of the paper, we were sampling organizations from a “hidden” network of unknown size and composition. As a result, there are no *a priori* data that allow us to compare percentages of different types of organizations in the observed CCSS network to the percentages of such organizations in the real CCSS network. We can, however, reason informally about this issue and in doing so, provide the reader with a rough sense of the plausibility of our estimates of CCSS network size and composition.

Our reasoning about the size and composition of the “real” CCSS network proceeds as follows. First, we briefly discuss various efforts to enumerate the total number of organizations of different types that exist in the American school improvement industry as a whole. These data, we argue, can provide the reader with a rough sense of the percentage of all such organizations that actually appeared in our observed CCSS network. Of course, organizations of different types in the American school improvement industry were not necessarily mobilized into the CCSS network at equal rates, but by looking at the number of organizations of a given type that exist in the American school improvement industry as a whole and then comparing this number to the number that appeared in our observed network, we can get a sense of: (a) the types of organizations that are *well*-represented in our observed CCSS network; and (b) types of organizations only *sparsely* represented. Then, we can use these fractions to reason about the extent to which our sampling procedure might have worked to identify particular kinds of organizations in the observed CCSS network.

We begin by discussing types of organizations that appear to be well-represented in our observed CCSS network. As one example, Rowan (2002: 288) reported that there were about 500 membership organizations in all of American education in the 1990’s. Although the data source Rowan (2002) cited did not use the same definition of a membership organization that we did in this paper, and although the total number of membership organizations in American education almost certainly changed since the 1990’s, the fact that we located 532 membership organizations in our observed CCSS network suggests that our sample included a large fraction of membership organizations in the American school improvement industry. As another example, sources cited in Rowan (2002: 309) found that there were about 400 different *for-profit* organizations providing research, development, technical assistance, and training to schools and school systems in the late 1990’s. In this light, our estimate that there were 497 (for- and not-for-profit) organizations in the observed CCSS network providing similar services (i.e., professional development, technical assistance, research services, and testing services) suggests that our observed CCSS network included a considerable fraction of these kinds of organizations as well, even if Rowan’s (2002) number included only for-profit organizations of this type. As still another example, the sources cited by Rowan (2002: 309, footnote 24) indicated that in 1997, there were about 30 publishers of mainstream textbooks in American education. To be sure, there has been substantial evolution in textbook publishing since 1997, with the industry becoming far less concentrated in the 2000’s than it was in the 1990’s due to the digital revolution. However the fact that the observed CCSS network

included 52 conventional (i.e., mostly print) publishers suggests that our observed CCSS network data included a fairly large fraction of the mainstream publishing firms in the U.S. school improvement industry.

Other types of organizations appear to be less represented in our observed network. As one example, in January 2021, the Foundation Directory Online listed 3,986 foundations that gave grants in the areas of primary and secondary education (for the purposes of curriculum development, policy, advocacy/systems reform, educational management, capacity-building/technical assistance, and educational testing). In this light, it is interesting to note that our observed CCSS network included only 144 foundations. Similarly, in January 2021, the Foundation Directory listed 11,045 organizations that received foundation grants for these purposes, whereas our data on the observed CCSS network included just 660 advocacy organizations. Given that we identified only a small fraction of all foundations and advocacy groups in American education as members of our observed CCSS network, we explored the Foundation Directory Online data further. That analysis suggested that the observed CCSS network reported in our paper included only a small fraction of corporate, family, and community foundations, many of which engaged in very local educational grant making. Moreover, the Foundation Directory Online data further suggested that our observed CCSS network included only a very small fraction of advocacy organizations operating at the local level. When taken together, these findings raise the possibility that our sampling strategy worked to under-represent the fraction of advocacy groups and foundations that actually participated in the CCSS network largely because we trimmed the hypertext linkage data on all local education agencies out of the data set. In doing so, we also might have trimmed away the links of these local education agencies links to local advocacy groups and foundations, leading to the relatively sparse presence of such organizations in our network data.

Finally, we are unaware of *any* data listing the total number of organizations in the U.S. school improvement industry that provide schools and schools systems with what (in the current paper) was called “instructional materials.” At the time Rowan (2002) was writing about the American school improvement industry, the market for instructional materials was largely centered on print materials and therefore Rowan (2002) provided no sense (or even discussion) of the number of organizations providing digitized instructional materials. By the time we collected data for the current paper, however, the market for instructional materials had been transformed by expansion of the internet and by the subsequent digital revolution in publishing. Unfortunately, we know of no effort to take a census of providers of these digital instructional resources, and as a result, we have no way of knowing what percentage of all such instructional materials providers is represented by the 652 instructional materials providers included in our data.

In light of this discussion, and as indicated in the main body of this paper, the reader should treat the data in Table C2 as provisional.

References

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