



## **The Power and Politics of STEM Research Design: Saving the "Small N"**

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## Abstract

Like all research, the analysis of minority experiences in STEM education, including research on patterns of inclusion and on the nature of classroom teaching and learning, requires methodological decisions. Rigorous scholars customarily attempt to match carefully research question to research design, and at the same time to incorporate realistic data collection aims and resource use. What is less often considered is the field of existing research options, as such; that is, the question of what may determine researchers preferences for quantitative or qualitative methods, for aggregated or disaggregated data. We see all of these methodological choices by STEM researchers as powerful indicators of social understandings of equity and inclusion, in this case regarding matters of equity in engineering equity. We ask here: What larger social conditions may be prompting STEM researchers’ ideas of practical and intellectually appropriate research design?

In this paper, we consider one such idea: The prevailing stigma of research conducted on small populations in research on equity. Whatever its source or however explicit (or not) its ideological origins, disregard of the “small n” population as non-meaningful reproduces a marginalization of students. It also casts particular human experiences as aberrant by virtue of statistical rarity. But most profoundly, researchers’ definition of small or large “ns” reiterates the value or necessity for established categories (say, racial demarcations, or binaries of ability and disability), while we instead believe that critical reflection on categories is necessary for any address of power and privilege. Our counter example to the prevailing “small n” stigma is the *Learning from Small Numbers* project, which uses narrative methods for analyzing the stories of participants’ lives to explore how race and gender (and other categories such as class) as macrostructures interact to race and gender engineering education institutions. We discuss the advances we see the LfSN project offers, and point out some remaining challenges these researchers must continue to wrestle with; we finish by outlining some possible methodological reframings for the field of engineering education.

## Introduction

Like all research, the analysis of minority experiences in STEM education, including research on patterns of inclusion and on the nature of classroom teaching and learning, requires methodological decisions. In addition to locating specific sites and subjects to be studied, researchers customarily choose between such investigative options as the collection of quantitative or qualitative evidence, or the use of aggregated or disaggregated data sets. Units of analysis, taxonomies, and nomenclatures are all matters of choice, as well. Rigorous scholars customarily attempt to match carefully research question to research design, and at the same time to incorporate realistic data collection aims and resource use. That researchers’ choices of instruments, such as surveys, interviews, or ethnographic observation, are discretionary is virtually always bluntly acknowledged in the published products of research; a “Methods” section is one hallmark of responsible science and social science writing. What is less often addressed by even the most thoughtful researchers, however, is the available *field* of existing research options, as such; the universe of possible, credible methodological choices or

evidentiary standards.<sup>1,2</sup> We believe that reflection on those parameters would support a more robust inquiry into STEM education subjects, as would explicit contextualization of researchers' chosen methods or standards along societal terms: that is, attention to the question of which societal conditions may determine researchers' embrace of quantitative or qualitative methods or their preference for aggregated or disaggregated data in a given project.<sup>3</sup>

We see all such choices by STEM education researchers as powerful indicators of social understandings of equity and inclusion and find the absence of routine inquiry about these conditions of research to be concerning. As Riley writes of one ubiquitous methodological commitment in particular, "The evidence-based process [of STEM education research] is instrumental in that it is a means to a given end, and the ethics or morality of those ends is not considered."<sup>4</sup> We see "ethics or morality" configuring all research choices and along with Riley, envision a set of critical questions that could potentially increase the impact of educational research upon social inequities. Such questions might include: What social ideologies may be prompting STEM education researchers' ideas of practical and intellectually appropriate research design (including in the case of our own work)? What societal conditions are reproduced through these ideas of meritorious, doable STEM education research? Which are challenged? That is: Are worrisome inequities along lines of race, ethnicity, (dis)ability, LGBTQ identity or age, among others, dismantled or perpetuated as STEM researchers select their subjects, shape their questions, and determine what "rigorous" research will look like? Can we codify characteristics of STEM educational research practice that may help us assure desirable, emancipatory outcomes from that practice?

In this paper, we consider one pattern in STEM education research design along these critical lines: The prevailing stigma of research on under-represented groups that is conducted on small subject populations. We follow this stigma as it shapes research on discrimination or minority under-representation in higher engineering education and find that STEM education scholars' distaste for the "small N" sometimes simply construes intersectionality as oddity, and depicts small-n research as focusing our attention on the rarity, the "Hispanic lesbian who uses a wheelchair."<sup>5</sup> Other researchers, focusing on seemingly practical investigational matters, describe themselves as aspiring to keep data on race and gender disaggregated in quantitative analyses of under-representation (with the hope of studying, say, women of color and white women separately), but as having insufficient numbers of participants of a particular "type" to justify doing so.<sup>6</sup> In other words, because of the small numbers of people of color in engineering, analysts deem it methodologically necessary to aggregate all women together even when subjects' experiences differ by race, or to aggregate all African American persons together even when their experiences differ by gender, losing not just nuance but entire lived experiences of engineering education.<sup>7,8</sup> In any inquiry where sheer numbers dictate viable populations for study, we risk dismissing curiosity about the forms of identity (for example, along lines of sexuality, dis/ability, nationality or age) that are associated with the most severe under-representation. Meaningful patterns of student participation in engineering higher education are seen to reside only in studies above a certain scale, as prevailing evidentiary standards determine what may and may not be subject *to* study. The quantitative methods of analysis espoused by engineering triumph and when applied to engineering education function to erase some identities altogether in analyses of under-representation.

We want to assail this seemingly unassailable approach to engineering education research, deconstructing its status as rigorous and objective, as “scientific” in conventional senses of that word. The idea venerated in experimental science that where a little evidence is good more evidence must be better, delineates the small-n population in STEM equity studies as a limited analytical resource, which in turn reproduces a marginalization of students of minority or intersectional identity.<sup>7,8</sup> If we question the downward limits of study population size in STEM educational research, we see that such limits cast particular human experiences as aberrant by virtue of statistical rarity. But our paper is emphatically not a call for “improved representation” for persons of particular backgrounds or life experiences. As critics have long pointed out, the idea that discrimination ends with representation itself “traffics in assimilationist goals, rather than attacking and undermining the very processes by which (some) subjects become normalized and others marginalized” (3).<sup>9</sup> Relatedly, as McRuer summarizes, representation is not a once-and-for-all attainment: “visibility and invisibility are not after all, fixed attributes that somehow permanently attach to any identity” (2).<sup>5</sup> Rather, we believe that small-n studies, relying on techniques such as qualitative analysis or narrative reporting by subjects, may shed light on individual and collective experiences that are far more layered than conventional STEM educational research normally admits.

Most profoundly, researchers’ very definition of their “n”s as small or large reiterates the analytic value or necessity for established and fixed categories (say, racial demarcations, gender differentiations, or binaries of ability and disability) that elide the lived experiences of subjects and researchers. As Ian Hacking famously put it, “Enumeration demands *kinds* of things or people to count. Counting is hungry for categories.”<sup>10</sup> The particularly “tidy identity categories” that downward limits on “n” size mandate (say, the go/no-go designation of a subject as a minority person or not...as an other or not...as having non-normal experience or not) carry risks of essentialism, positioning students, researchers, and study patrons or audiences alike within those categories. As Fifield and Letts make clear, such sorting will readily “reduce the self to normalized and naturalized identities” at “great convenience to the continuance of scientific norms and expectations and great loss to emancipatory educational reform.”<sup>11</sup> With these social instrumentalities of quantitative research in mind, we might now ask still more questions, this time about the larger intellectual arena in which STEM education researchers (including ourselves) seek reputational security: Why do disciplines count the things they do? What roles do funding institutions or peer expectations play in perpetuating such counting priorities? And do social structures such as race or class undergird those institutional and peer group impulses? We suggest that constant critical reflection on analytic categories is necessary for any address of power and privilege and that exploring “n” size in STEM education research may reveal, “...just how much work it takes and how much diversity must be ignored to construct scientific understanding” of identity and experience in higher engineering education (402).<sup>11</sup>

Our counter example to the prevailing small-n stigma in STEM equity research is the project, *Learning from Small Numbers* (LfSN) currently being undertaken by one of us along with her colleagues at Purdue University and University of Georgia. This study of engineering students at multiple American universities uses “voice-centered interpretation” to analyze participants’ stories of their lives in and beyond the university, and in this way explores how race and gender (and other categories such as class) as social macrostructures interact with one another. To the stories collected through an open interview protocol, the LfSN researchers apply a multi-step

analytical standard operating procedure in which the researchers first trace the “characters” and “plots” outlined by participants, and then mark and reflect on the different “ruling relations” that influence those experiences.<sup>12,13</sup> The LfSN team members then trace the voices each participant uses to tell different parts of his/her story (paying particular attention to points when subjects speak about a disembodied “they”). The next step involves the team drafting storied cases from the participants’ stories. Between each major step, the researchers undertake a reflexive memoing addressing what this step has taught the researchers about race, class and gender, including intersectionality, and how each researcher’s own race, class, and gender may be influencing his/her analysis.<sup>14</sup> This team has elsewhere written more specifically about the project’s approach to analysis,<sup>15, 16</sup> which resonates with a small but highly suggestive body of work integrating qualitative and ethnographic methods into STEM equity research.<sup>17,18</sup>

One procedural note: as we move into this paper, we find ourselves confronted with an awkwardness in how to refer to ourselves, the authors of this paper, as members of a project distinct from that of the LfSN researchers, considering that Alice is a member of both groups. In general, we have chosen to refer to the people working on the LfSN project in the third person rather than the first, using “the LfSN researchers” or “they” rather than “we” to distinguish that set of researchers from the author team now speaking to the reader. However, this functions to help the readers forget the problems with the we/they distinction, a problematic outcome. We (the authors of the paper you now read) hope that, by drawing explicit attention to this here, the readers will forgive us the rhetorical – but not inconsequential – decision to separate the voices this way in the remainder of the paper. It is only by embracing such challenging reflexive tasks, we believe, that the positionality of all researchers, ourselves included, may be exposed.

In essence, students’ stories drawn out through the LfSN project are approached by the research team as *entrées* into better understanding how the structure of engineering education functions inequitably to maintain engineering as a white, male conclave. LfSN also seeks to embed profound reflexivity regarding researchers’ own stories and positionalities. In this paper we explore the emancipatory potential of these features of small-n STEM research through the lenses of Queer Theory and Disability Studies, first laying out emergent critical priorities of those fields and then the particular potential of LfSN, and similar projects engaging with qualitative methods and small populations, to disrupt conventional STEM equity research. We recognize that small-scale qualitative research on raced and gendered institutions will not *necessarily* achieve such disruptions. Among other things, we need to ask: does attention to individual students’ experiences, on which LfSN relies, not run the risk of capture by neoliberal agendas for (and definitions of) diversity that center precisely on individual “achievement,” or even more destructively, “grit”?<sup>5,9,19,20</sup> There is no question that a great many contemporary invocations of “tolerance” in U.S. higher education are nothing if not celebratory of the efficacious individual, summoning meritocratic agendas as the optimal route towards a just, post-identity democracy.<sup>21</sup> Complex debates regarding the reformist potential of identity politics versus a sort of activism based on more fluid and contingent categories, sometimes called “post-identity” work, must also be engaged. But we arrive at a positive answer to the question of whether or not small-n research may support liberatory projects, powerfully challenging the meritocratic triumvirate of talent/obstacles/attainment that configures so much STEM equity research and policy. We close with some thoughts about the impediments such a challenge may face.

## How Research Methods Produce Identities

In the study of how equitable opportunities may best be achieved in STEM education, as in all scientific and social science research, our methodologies derive from our presumptions about our subjects and ourselves.<sup>3,4</sup> Thus, our investigations should not be seen primarily as constituting measurements of phenomena, but as ontological projects that produce phenomena. Race, gender, sexuality, intellectual ability and disability--all such ascriptions routinely shaping our studies of STEM education equity can in this light be seen as gaining meaning from our own particular interpretive commitments. When we look for markers of racial difference or evidence of student abilities, we will find these, and not some other information. This is an outlook that is supported by educational research inflected by Pragmatism (including, as Biesta and Burbules show, Dewey's understanding of knowledge as doing<sup>22</sup>); by histories and sociologies of science shaped by social constructivism,<sup>23</sup> and by a more recent ontological turn in the field of Science Studies.<sup>24</sup> Through all of these approaches ideas regarding what counts as evidence, and how, are made far more complex than would appear to be the case from conventional educational research, in which subjects are rarely identified and teaching and learning processes rarely described with any reference researchers' own positionality. We do not claim that this ontological character means that customary STEM education research is fraudulent or necessarily unhelpful in the cause of equity, or that some alternative "objective" and non-relational type of research can exist. To the contrary: this relational feature of STEM education scholarship is an inescapable condition of research and by interrogating it we may increase the impact of our studies.

This critical, reflexive project implicates all so-called scientific approaches to the study of education and its impacts, helping us to question value-neutral characterizations of, say, "the gold-standard" of educational research, "randomized field trials."<sup>3</sup> To understand the values driving such research, we can draw on two helpful bodies of recent critical thought that focus on ontological process: Queer Theory, which helps us systematically question the idea of selves as stable, knowable types; and Disabilities Studies, which takes as its critical object the naturalization of human differences in modern cultures. Both areas of scholarship provide important tools for our look at "n" size as a factor in the political nature of STEM education research.

If quantitative human sciences research (whether deploying large or small numbers of subjects) relies on the use of categories (delineating white, black or brown subjects; healthy or ill subjects; subjects of particular genders; students of various achievement levels, etc.) as the basis of its systematic inquiry, then recent Queer Theory prompts us to question the social origins and functions of category-making. While identity rights movements and many forms of diversity activism advocate for the increased representation of persons identified as minority in various social sectors or institutions, the "queering" of Queer Theory (to oversimplify a complex heuristic) asks instead that we deny such neat identifications of persons with personhood. We might think of "personhood" as including everything that matters about an individual in a given setting; including "identities" along familiar lines of "race" or "gender," but also, say, the sense that an individual is a potential member of a workforce or future immigrant or likely disease vector. In the light of Queer Theory, no such personhood, no association of characteristic with individual, exists as a "sheer positivity," but each instead can be seen to derive from social relations.<sup>23</sup> The idea of stable, knowable human types is seen by Queer Theorists to have

historically empowered privilege and oppression. As Giffney explains, in contrast to its sometime use as an identifier of gay, lesbian or transgendered persons,

Queer is more often embraced to point to fluidity in recognizing identity as a historically contingent and socially constructed fiction that prescribes and proscribes against certain feelings and action. It signifies the messiness of identity...<sup>(2)</sup>.<sup>26</sup>

Queering embraces contradiction and deeply challenges science as customarily practiced by questioning the comforts that enterprise offers by way of empiricism and certainty. It is not merely the experimental findings of science that provide such false comfort, we may recognize, but the very framing of questions scientifically, on the presumption of demarcated, unchanging objects of inquiry (such as human types and individuals expressing characteristics of those types).<sup>11</sup>

There is a rich vein to tap here on the inherent conservatism of positivist science, and as Fifield and Letts capture nicely, we might conversely best characterize “learning” as “a love of putting the self at risk.”<sup>11</sup> Riley similarly incites us to consider the indeterminate relationship of knowledge and resistance.<sup>4</sup> But our aim in this paper is not to focus on science writ large but on the scientized conventions of STEM education research. Britzman beautifully captures how essentialism runs through identity claims that “take on an aura of verisimilitude and hence are taken as if they can exist outside of the very history and differential relations that provoke such claims and attendant feelings in the first place...”<sup>25</sup> The potential of LfSN and similar projects to challenge such elisions resides not directly in their scale (small) but in their willingness to engage with indeterminacy; a flexibility that a sheer accumulation of subjects along predetermined lines (inherent in the large-N inquiry) works against.<sup>17,18,27</sup> To an unusual extent LfSN researchers strive to avoid presuming the groupings/experiences/demarcations that give form and meaning to STEM education experiences prior to starting their investigation. To be clear, those groupings are not absent from LfSN research: Certainly notions circulating in American higher engineering education about racial or economic differences drive their study and funders’ support for such scholarship. But in encounters with subjects, the researchers are open to the possibility that a participant enlisted in the study as a Black woman or Latino man may derive a sense of self from some experiences or categories not yet invoked or even imagined by the research team. These small-n researchers consider divergence among subjects to be incessant and inevitable, the use of categories and types and counting to be inherently problematic, and the nature of what may work as evidence in the LfSN project itself to require constant reflection.<sup>16</sup> We discuss below specific ways in which the lessons of Queer Theory may be seen to resonate with LfSN’s self-questioning and findings.

The overlaps between Queer Theory and Disabilities Studies, for example in the emergent field of “Crip Theory,” are many, and we want to highlight here one way in which Disability Studies builds well on the fruitful “irritations” of identity that Queer Theory enables.<sup>5,11</sup> In recent years, Disabilities Studies scholars have cast a raking light on the means by which human sciences have historically determined that differences among individuals (bodily or intellectual) can be detected, measured and (potentially) remediated. For example, “medicalized” ideas of physical disability delineate impairments or deficiencies that scholars now recognize to be based on social normativities. By contrast, “social” descriptions of the same human experiences instead

articulate interactions of persons and environments that have produced disadvantages for those persons. In other words, disability inheres not in individuals but in built, regulatory, or social environments.<sup>28</sup> This idea clearly dovetails with Queer Theorists' invocation of complex, unknowable selves and supports an ontological inquiry into social relations. But Disabilities Studies, in problematizing the scientific production of human capacity and its absence, also helps us interrogate the process by which scientific research demarcates what will count as meaningful human characteristics, advantageous or otherwise. This demarcation is another feature of STEM education research that is rarely analyzed and with which LfSN and similar studies critically engage.

In some sense, the observation that scientific research on humans necessarily demarcates meaningful human characteristics may sound like a trivial observation: For the nutritional researcher, a person's weight may be significant and his or her level of manual dexterity meaningless; for an industrial training specialist, dexterity comes to the fore and weight may have no meaning; for a car safety analyst, drivers' manual dexterity and body size may both have meaning...and so on. But Disabilities Studies urges us to consider that the very idea of weight or manual dexterity are always and already measured against some bodily norm, each individual "reading" of a body placed upon a spectrum, and so the "obese" or "disabled" population must of necessity come into being alongside the "healthy" and "fit" and "dexterous." In exactly the same way, the challenged or unimpressive student comes into being alongside the meritorious and accomplished. Thus we can see that the choice to compare bodies or minds or achievements along such spectrum is just that: a choice. What's more, we can see that the choice to designate some individuals as being "at the ends of the spectrum" is both a socially disempowering gesture and one that naturalizes research on these demarcations. The acts of finding, measuring or recording of individuals' characteristics do not merely detect the presence or absence of a characteristic and relative degrees of such a characteristic in individuals; these acts also ensure the existence of different *types* of individuals.

Without explicitly making populations identified as "queer" or "disabled" its subjects, the LfSN project echoes characteristics of Queer Theory and Disability Studies in a number of ways, differing from traditional STEM equity research. First, it understands STEM students' experiences of identity (say, "race" "gender" or socio-economic status) to reflect "ruling relations," and proceeds from a dynamic understanding of those categories in culture. Second, in declining to seek "representative" experiences among its subjects' self reports, but rather to understand how institutional conditions and individual experiences interact, the project confronts divergence at every turn and allows subjects agency in research design.<sup>3</sup> Finally (and unusually among STEM education research projects), LfSN is predicated on reflexivity, focused on the generative and thereby researcher-privileging nature of research design. We discuss each of these features in the next section.

### **How Small-N STEM Education Research Speaks to Power**

Committed to avoiding the consolations of type and typologies (a central device of more conventional educational research) the LfSN researchers treat power (difference) as process, as a phenomenon and a landscape continually produced by and productive of institutions. Like much STEM research, LfSN's authors want to understand distributions of power in the university, in engineering professions, and in the larger society and how those distributions follow ascriptions

of color, gender, age, class, or ethnicity. It is important to note that a great deal of research on equity in higher education finds conventional notions of difference (along typologies of race, gender or class) to be highly problematic, and strives to undercut the oppressive uses of such delineations in our culture. But in allowing students to tell stories of their own devising, the design of LfSN treats intersectionality not simply as an accumulation of ascribed identities (race, plus gender, plus sexuality, plus class, etc.) but as a set of dynamic and unpredictable productions. Consider how the case studies discussed in LfSN's 2014 publication<sup>16</sup> include students' reports of occupational ambitions that have both empowered *and* exhausted the students, hard work sometimes carrying as much or more punishment for these individuals as reward. These intricate narratives of effort and outcome powerfully expose the neo-liberal conception of driving ambition as an element of merit. LfSN tries to make clear that it is impossible to judge these subjects at any point in their careers as clearly having failed or succeeded, but nor are subjects' narratives confused. To the contrary, lived experiences of education, work, health, family and community are vivid in the extreme. To the STEM education researcher seeking a more reflexive approach, the LfSN researchers' elicitations of students' individual stories, which are messy and disordered from the perspective of "lessons to be learned," instead and valuably, "put at risk illusions of a unitary, sovereign self," in the terms offered by Fifield and Letts (400).<sup>9,11</sup>

A second sense in which LfSN disrupts conventional STEM education research centers on the ways in which qualitative evidence poses a retort to such quantified data as standardized test scores; GPAs; and recruitment, retention, graduation and job placement rates. Even more exciting, the stories that constitute the raw material of this small-n research are revelatory of the nature of those data sets *as inscriptions*. In light of the messy, relational narratives produced by LfSN, each of those familiar measures of minority educational inclusion appears to be a selective and narrowed window on the experiences of learning and teaching. On one level, the LfSN stories reveal the twinned experiences of yearning and shame inhering in the schooling of those presumed by policy makers to be disadvantaged. Where learning and working are seen to reflect individual capacity as they are in U.S. STEM education policy rhetoric, not learning or not working most properly induce shame for the aspirant, rather than questions about, say, public funding for education, or child and elder care, or discriminatory hiring. Shame and self-doubt legitimate the system; without them attainment and grit have no meaning. More and more STEM education research, as noted, now interrogates the student experience of low self-efficacy or self-confidence as a contributing factor to minority under-representation, but unusually, LfSN asks us to interrogate the political instrumentality *of that interrogation*. It helps us ask: Where does such analytical emphasis on individual agency locate responsibility for educational attainment or its absence? On another level, acknowledging the differences between this qualitative research and customary quantitative studies of STEM education regarding causal factors lets us see the "reciprocally constituted relations" between morals and ethics on one hand and scientific conduct on the other. This suggests still more ways in which thinking about N-size may constitute a powerful critique of scientific scholarship in our culture.<sup>11</sup>

The third and closely related way in which LfSN unsettles customary approaches to STEM education research involves the researchers' engagement with knowing. In the design of LfSN, certainty is not to be achieved through a denial of complexity but through its embrace: Divergence within and among students' narratives (that is, unruly data for the LfSN researchers)

is not simply permitted in LfSN; it is welcomed as a step towards understanding the ruling relations of STEM institutions. Avoiding the conventional reliance on ascribed identity (that is, STEM education researchers' usual sense that they know "who" is being studied), LfSN begins to, as Britzman might frame it, "defy the certitude and indeed the very possibility of education" (151).<sup>23</sup> Britzman, writing two decades ago, transformatively asked that we see the global AIDS pandemic and gay and lesbian civil rights movements as constituting the possibility for this productive defiance. We would suggest now that from within the world of educational research, insistence on the incoherence of selves, as the design of LfSN encourages, might in turn upend the consoling vision of education and knowledge as empowering. Our ontological perspective indicates that self and knowledge are invariably coproduced. To presume that more and better knowledge awaits any willing citizen is naïve, and the stories show this clearly.

One final element of LfSN bears emphasis here if we are to probe its reformist potential: The authors of LfSN essentially treat themselves as a small population, a small *n*. In the body (note: *not* in a foot- or contributor's note) of their 2014 publication,<sup>16</sup> both researchers provide biographies, and what is more, these biographies, like their student-subjects' narratives, meld what we normally call personal and professional aspects of the researchers' lives, describing family backgrounds alongside professional credentials. In so doing, Alice and Canek counter the scientific norm of "writing from nowhere." But recall that the very purpose of using "voice-centered interpretation" in the conduct of LfSN is to decenter the researchers. Decentering should be understood as the opposite of deposing; in this case, calling attention to the researchers as thinkers and writers making choices forces us to attend to their social positionality. With this decentering, the researchers of LfSN help us deny STEM research as a monolithic category or a disembodied knowledge-finding process, and insist that it be seen as a form of power in practice.

It would not do to idealize any of these research choices as a certain route towards social reform. Without the possibility of failure, of illegible "findings" waiting at the end of the LfSN, deep reflection on the part of the researchers would be impossible. We (the authors of this current article) are in turn a small *n*, and our "findings" are as relational as any other; we should strive to be hesitant around certainty, ourselves. Without a doubt some of the limitations of LfSN as an intervention into STEM scholarship jump out immediately: If finding patterns in student experiences stands in the way of admitting human and social divergence, what *is* to be taken away from small-*n* studies? Here, small- and large-*n* research projects face some of the same problems. Continuing on to question the political value of *uncertainty*, we could ask: Does researcher reflexivity really empower transformative social change, or stand in its way by inducing a paralysis of "experimenters' regress" whereby the value lent to experimental results is understood to derive from experimenters' notions of what results are and are not reasonable?<sup>29</sup> No less important: in the operations of the academy, refereed journal, or funding agency, it's clear that what's good for small-*n* equity research is bad for the furtherance of identity politics and vice versa. One approach seems bent on parsing human experience and the other on fostering collectivity. But intersectionality is a relatively new epistemic and we are a long way from being sure that these are even two distinct ontological categories, so that anxiety probably requires more careful analysis.

Yet Biesta makes the crucial point that in a great deal of educational research today, "what works?" is argued from cause<sup>3</sup>; put differently, researchers' ends are stealthily determining

research means in educational studies, desired interventions determining empirical priorities<sup>4</sup> (not coincidentally, educational performance standards and tests exist just for this reason: to delineate some phenomena and render them as indicative of some condition<sup>30</sup>). There is no question that LfSN steps back from that self-serving and conservative development, again hinting a disruptions of the uses of science more broadly. And we are urged in no uncertain terms by Queer Theorists to consider that where “complexity and indeterminacy prevail, there is little here on which to hang equity and inclusion as they are normally conceived” (395),<sup>11</sup> an incompatibility which, we hope we have made clear, is all to the good.

### **Conclusions: Serious Impediments to Further Small-N Thinking (or, What to do Next?)**

Because we are excited by the potential of the LfSN approach, we want to close with a quick survey of obstacles such research seems likely to encounter. Beyond just the familiar rubrics used in social science to identify sufficiently representative objects of study (in the case of STEM education research, this would be “legitimate” quantities of human subjects), other conventions of human-science research prevail in definitions of rigorous STEM education research, and we lay those out here in hopes that others will help us study their political implications.

First, as any researcher who has encountered an Institutional Review Board knows, there is a universe of thinking regarding “fairness” that impedes criticality about evidence, as legal departments and administrative offices dictate relationships between researcher morality and method. IRB demarcations of “risk” and “harm” demand all manner of epistemic and ontologic certainty that we can’t examine here, but suffice it to say that one of us has encountered official IRB training in our home institution that distinguishes between quantitative and qualitative investigations, associating greater subject risk of harm with the latter. What hope for messy narratives and small subject populations with that medical model prevailing?<sup>25</sup>

Next, powerful norms regarding the unique objectivity and empiricism of experimental sciences require that research be replicable, a priority that is inherently contrary to small-n STEM education researchers’ recognition of intersectionality and its unpredictable nature.<sup>1,3</sup> There is little tolerance in educational research projects for the production of multiple or conflicting results; such results, which may prohibit even the possibility of reproducible studies, tend to signal to analysts not the existence of multivalent learning and teaching experiences in STEM but rather poorly designed research. Again, adherence to a belief in the universality of rigorous scientific findings impedes reflection on sciences’ imperial aims.<sup>11</sup> And there’s still more to worry small-n enthusiasts: As Bergsonian philosophy tells us, for information about the world to present as such to human perception, a kind of “chopping” in time and space is required, in order for the observer to distinguish a knowable materiality from the continuity that is nature. Yet LfSN researchers, listening to their subjects’ multi-directional life stories and shifting voices, traffic in infinitely mobile boundaries around human experiences. A STEM graduate’s hiring in a new job may constitute both a triumph over economic insecurity and a profound disruption of family relations; bringing both gain and loss at once. Or that employment prospect, carrying the graduate to a new locale or social circle, may pale for a subject in comparison to the continuity of a community membership.<sup>16</sup> In other words, the LfSN research team’s metrics are not unsystematic but they are also not entirely predictable, and the project is antithetical in this sense to some familiar tenets of scientific research and description. That insistent chopping, built into

numeracy and even descriptive language itself, is extraordinarily difficult to question in the activity we recognize as research without coming to seem sloppy or unclear about analytical aims. This is all philosophically fascinating and deserving of more study, but for the educational researcher hoping actually to embrace indeterminacy, daunting.<sup>33</sup>

Good intentions will not save the day. When STEM education researchers act on the basis of social justice concerns, we/they take up a generous or concerned position, which is dangerously close to reproducing the relationship that Britzman incisively describes as that of the “tolerant normal and the tolerated subaltern” (160).<sup>25</sup> In writing this paper, we have stepped back from the brink of indeterminacy ourselves at many points in the interest of making a persuasive case along the lines of conventional scholarship; no small dilemma given our analytical aims. But more to the point: How close have we come, in writing (or respectfully reading) this piece to “confirming” ourselves “as generous”? Most provocatively for the STEM education researcher or activist, Britzman brilliantly reminds us that, “the lived effects of inclusion are a more obdurate version of sameness and a more polite version of otherness” (160).<sup>23</sup> Here we have to say, simply, ouch.

But if the researchers’ selves can be kept perpetually at risk of such painful prodding (perhaps precisely by keeping in sight the possibility of becoming the infinitely small N, the “n” of zero who stops doing research or cannot validate her work), we see some hope. Biesta hopes for an expansion of “our views about the inter-relations among research, policy and practice in order to keep in view the fact that education is a thoroughly moral and political practice” (6),<sup>3</sup> and we believe that projects like LfSN may help keep our vision trained in just that direction.

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### References

1. Beddoes, K. (2014). Methodology discourses as boundary work in the construction of engineering education. *Social Studies of Science*, 44(June 2013), 293–312. DOI:10.1177/0306312713510431
2. Jesiek, B. K., Newswander, L. K., & Borrego, M. (2009). Engineering Education Research : Discipline, Community, or Field ? *Journal of Engineering Education*, 98(January), 39–52. DOI: 10.1002/j.2168-9830.2009.tb01004.x
3. Biesta, G. (2007). Why “What Works” Won’t Work: Evidence-based Practice and the Democratic Deficit in Educational Research. *Educational Theory* 57 (1): 1-22.
4. Riley, D. (2014). What’s wrong with Evidence? Epistemological Roots and Pedagogical Implications of “Evidence-based Practice” in STEM education. ASEE Annual Conference, Indianapolis, IN.
5. McRuer, R. (2006). *Crip Theory*. New York: New York University Press.
6. Litzler, E.; Mody-Pan, P.N.; and Brainard, S.G. (2011). Intersections of Gender and Race in Engineering Education. ASEE Annual Conference, Vancouver, BC, Canada.
7. Ong, M.; Wright, C.; Espinosa, L.L.; and Orfield, G. (2011). Inside the Double Bind. *Harvard Educational Review* 81 (2): 172-208, 389-390.

8. Turner, C. (2002). Women of Color in Academe: Living with Multiple Marginality. *Journal of Higher Education* **73** (1): 74-93.
9. Luhmann, S. (1998). Queering/Querying Pedagogy? Or, Pedagogy is a Pretty Queer Thing. In W. Pinar (Ed.), *Queer Theory in Education* (pp. 141–155). Mahwah, NJ: Lawrence Erlbaum.
10. Hacking, I. (1982). Biopower and the Avalanche of Printed Numbers. *Humanities in Society* **5** (3 & 4): 279-295.
11. Fifield, S. and Letts, W. (2014). [Re]considering Queer Theories and Science Education. *Cultural Studies of Science Education*. **9**: 393-407.
12. Smith, D.E. (1990). *Texts, Facts and Femininity: Exploring the Relations of Ruling*. London: Routledge.
13. Smith, D.E. (2005). *Institutional Ethnography: A Sociology for People, Gender Lens*. Lanham, MD: Altamira Press.
14. Crenshaw, K. (1989). Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory, and Antiracist Politics. University of Chicago Legal Forum.
15. Pawley, A. L. (2013). Learning from small numbers of underrepresented students' stories: Discussing a method to learn about institutional structure through narrative. In *Proceedings of the ASEE Annual Conference and Exposition*. Atlanta, GA.
16. Pawley, A. L., & Phillips, C. M. L. (2014). From the mouths of students: Two cases of narrative analysis to understand engineering education's ruling relations as gendered and raced. In *ASEE Annual Conference and Exposition*. Indianapolis, IN.
17. Walther, J., Sochacka, N.W. and Kellam, N.N. (2013). Quality in Interpretive Engineering Education: Reflections on an Example Study. *Journal of Engineering Education* **102** (4): 626-659.
18. Stevens, R., et al. (2008). Becoming an Engineer: Toward a Three Dimensional View of Engineering Learning. *Journal of Engineering Education* **97** (3): 555-568.
19. Slaton, A.E. (2011). Metrics of Marginality: How Studies of Minority Self-Efficacy Hide Structural Inequities. ASEE Annual Conference, Vancouver, BC, Canada.
20. Duckworth, A.L.; Peterson, C; Matthews, M.D. and Kelly, D.R. (2007). Grit: Perseverance and Passion for Long-Term Goals. *Journal of Personality and Social Psychology* **92** (6): 1087-1101.
21. Riley, D.; Slaton, A. E.; and Pawley, A. L. (2014). Social Justice and Inclusion: Women and Minorities in Engineering. In A. Johri and B. Olds, eds., *Cambridge Handbook for Engineering Education Research* (pp. 335-356). Cambridge: Cambridge University Press.
22. Biesta, G. and Burbules, N.C. (2003). *Pragmatism and Educational Research*. Lanham, MD: Roman & Littlefield.
23. Shapin, S. (1995). *A Social History of Truth*. Chicago, University of Chicago Press.
24. Law, J. and Lien, M.E. (2013). Slippery: Field Notes in Empirical Ontology. *Social Studies of Science* **43** (3): 363-378,
25. Britzman, D. (1995). Is There a Queer Pedagogy? Or, Stop Reading Straight. *Educational Theory* **45** (2): 1-22.
26. Giffney, N. (2009). Introduction: The “q” Word. In N. Giffney, ed., *The Ashgate Research Companion to Queer Theory* (pp. 1-13). Farnham, Surrey, UK: Ashgate Publishing
27. Adams, R.S., et al. (2011). Multiple Perspectives on Engaging Future Engineers. *Journal of Engineering Education* **100** (1): 48-88.
28. Davis, L. J. (2014). *Disabilities Studies Reader*, 4<sup>th</sup> Edition. New York: Taylor & Francis.
29. Shapin, S. and Schaffer, S. (1985). *Leviathan and the Air-Pump*. Princeton, NJ: Princeton University Press.
30. Slaton, A.E. (2010). *Race, Rigor and Selectivity in US Engineering: The History of an Occupational Color-Line*. Cambridge, MA: Harvard University Press.
31. Bennett, J. (2010). *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.