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FIELD DISRUPTIONS AND FIELD CONNECTIONS

Urban Mathematics Education Research: Using Citation Cartography to Map Bubbles and Foams in Mathematics Education Research

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> Objective history is meant to function like a mirror that provides us with a reflection of the past. In contrast, effective history is meant to function like a lever that disrupts our assumptions and understandings about who we think we are. Foucault's history, with its provocative and ironic stance, conveys the message that mirrors make the best levers. (Fendler, 2010, p. 42)

Similar to Foucault's ironic approach to history, suggesting that perhaps mirrors make the best levers, I contend that perhaps connections can make the best disruptions. To wit, in this paper, I will introduce citation networks that literally make connections between articles and citations as a way of disrupting assumptions about what has been and can be done in the name of mathematics education research.

The purpose of this paper is to introduce citation networks, a novel method for identifying field connections (Section 1), and to elaborate a theory of spatiality that deploys the metaphors of bubbles and foams to imagine space and change (Section 2). After introducing the method and theory that guide this investigation, I will introduce and describe the foams of the research published in the *Journal for Research in Mathematics Education* (*JRME*) and *Educational Studies in Mathematics* (*ESM*) during the 2010s (Section 3). In doing so, I will show what topics of inquiry constitute the dominant research foci of our field, or at least of our field as it is published in these mainstream mathematics education journals. Then, using Larnell and Bullock's (2018) socio-spatial urban framework as a lens, I provide a critical reading of the bubbles and foams to discern what is marginalized or excluded, namely the *urban* (Section 4). After investigating the inclusion of "urban," I conclude by situating the role of the *Journal of Urban Mathematics Education* (*JUME*) as a place to blow bubbles (Section 5) and reconfigure what we can see, say, think, and do in the name of (urban) mathematics education research. Furthermore, although *JUME* is notably absent from the present analysis, a citation network analysis of *JUME* constitutes the focus of a forthcoming paper (Dubbs, 2021a).

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1. Citation Networks: A New Tool for Identifying Field Connections

Citation networks, in the way that I have undertaken them, are *maps*. Each published article and each of the articles, books, chapters, etc. that an article cites are represented with circles (called nodes). Two circles are connected with directed line segments (·→∘; called edges) if one cites the other. The radius of the circle is proportional to the number of times it is cited (larger circles are more cited). Then, once these networks are generated via specialized software, additional algorithms are applied that encode topical relatedness in spatial closeness (Noack, 2009). A discussion of the method of map generation, analysis, and presentation constitutes this section.

This citation network method draws on both historical and contemporary research, and this section introduces some relevant literature on citation networks and the study of scientific fronts. Although these articles establish a few significant points in the history of citation network analysis, and a glimpse into the larger field of information science, I refer the reader to Chen's *Mapping Scientific Frontiers: The Quest for Knowledge Visualization* (2013) and Scharnhorst, Börner, and van den Besselaar's *Models of Science Dynamics* (2012) for a more complete orientation to such endeavors.

A History of Citation Networks

In 1965, Derek de Solla Price published the seminal "Networks of Scientific Papers" in *Nature*. In that work, Price "attempt[ed] to describe in the broadest outline the nature of the total world network of scientific papers" (p. 510) based on paper citations. Building upon the characterization of citations within scientific disciplines, Narin, Carpenter, and Berlt (1972) sought to understand the ways that different scientific journals cited each other. These researchers developed citation relationship models that traced the flow of information from Mathematics to Physics to Chemistry to Biochemistry to Biology and identified the key journals that served as *disciplinary bridges*.

Within this history of citation network analysis, the Institute for Scientific Information's *Atlas of Science: Biochemistry and Molecular Biology 1978-80* (1981) moved closer to the project that this analysis undertakes. The *Atlas* was experimental and served as a proof of concept for the technique of clustering and citation mapping. In the *Atlas*, Garfield and his team identified 102 research front specialties within the field of Biochemistry and Molecular Biology and provided a Global Map that situated the 102 clusters relative to each other. Unfortunately, the Institute for Scientific Information did not publish additional volumes in the Atlas of Science series, and the *Biochemistry and Molecular Biology* volume was the only one to be published.

Citation analyses have had continuous uptake since these groundbreaking studies, particularly in the sciences and engineering: patent analysis (Englesman & van Raan, 1994; Noyons & van Raan, 1994), bibliometric analysis of bioelectronics

(Hinze, 1994), and scientific landscape analysis of sustainability science (Kajikawa et al., 2007). Uptake in education research has only happened in recent years (Bruce et al., 2017; Nylander et al., 2018; Özkaya, 2018; Wang & Bowers, 2016; Weller et al., 2018).

Largely, the citation networks in education research have considered topics outside of mathematics education per se, a trend exemplified by studies that focus on which researchers cite which others in the adult learning literature (Nylander et al., 2018), which journals cite which others in the educational administration literature (Wang & Bowers, 2016), or mapping the open education literature (Weller et al., 2018). The work by Bruce and colleagues (2017) began to bridge this citation network analysis work into the realm of mathematics education. There, Bruce and colleagues mapped the flow of knowledge on "spatial reasoning" between disciplines and argued that mathematics education, as a transdisciplinary endeavor between psychology, education, and mathematics, among others, is uniquely situated as a bidirectional bridge of information between these other areas.

Unlike Bruce and colleagues' (2017) work, which used the topic of spatial reasoning as its focus for citation network mapping, Özkaya (2018) used Chen's (2006) CiteSpace (discussed in the next section) to analyze the mathematics education articles published since 1980 and indexed in Clarivate's Web of Knowledge (WoK) database. Given the limitations of WoK, discussed in the next section, Özkaya's findings on author's country of origin, most cited articles, and keyword analysis are limited in both accuracy and depth. The present analysis moves beyond Özkaya's descriptive measures and towards an analysis that illuminates clusters of research foci.

Software for Citation Network Analysis

My goal, now, is not to provide a complete overview of all possible software choices for citation network analysis. Instead, I refer the reader to Cobo et al.'s (2011) extensive review of software choices and Pan et al.'s (2018) detailed study on the use of software by researchers for different purposes and across various disciplines. Instead, I introduce a few of the software tools that researchers have used for citation network analysis, identify in what way they are inadequate for my present analysis, and conclude by introducing Gephi, the chosen software.

One possibility is the use of the statistical software R and the *bibliometrix* package (Aria & Cuccurullo, 2017), but the visualization options and citation network options are limited. Other well-documented software, such as CiteSpace (Chen, 2006), CitNetExplorer (van Eck & Waltman, 2014), and VOSViewer (van Eck & Waltman, 2014, 2017), are dependent on Clarivate's WoK citation database, which does not fully index key mathematics education research journals (i.e., *JRME*, *JUME*, *ESM*, etc.; this reiterates the limitation of Özkaya's, 2018, study). Another well-documented choice is Garfield's (2009) HistCite, but support was discontinued by Clarivate (2021).

Gephi (Bastian et al., 2009) is an open-source tool for creating, analyzing, and visualizing citation networks. Like bibliometrix, Gephi is an integrated solution for importing, analyzing, and visualizing citation networks. First, Gephi can import spreadsheets of data directly, given that it contains either a list of articles (nodes) or a list of article-to-article citations (edges). Further, it can analyze and visualize very large networks (up to 1,000,000 nodes and edges) and generate both static and interactive maps. Given, then, that Gephi is not dependent on the WoK database and can create both static and dynamic representations, I chose Gephi as the software of choice for the present analysis. Other researchers facing the same WoK limitation (e.g., Nylander et al., 2018) likewise chose Gephi.

Data Preparation

There are a few options for sourcing citation data: references can be manually extracted from published articles, reference information can be extracted from an article database such as JSTOR, or the references can be extracted from an existing database of citation relationships such as Clarivate's WoK. JSTOR, it turns out, is the most convenient option. Although JSTOR stores the articles for both *JRME* and *ESM* as PDF files, JSTOR has also extracted every reference from every article and lists them on the JSTOR article webpage. Even with this text easily copied and pasted from the JSTOR page to a spreadsheet, manually extracting this data would be time prohibitive because *JRME* published 177 articles between 2010 and 2019 and *ESM* published 445 articles between 2010 and 2016.[1] To automate this process, I developed a software tool in Java, JSTORrefextract, detailed elsewhere (Dubbs, 2021b), that extracts the necessary citation data from the JSTOR article webpage HTML files and generates formatted Microsoft Excel files that can be imported into Gephi. Because this process from data identification to analysis involves numerous, yet well-defined, steps, I include Figure 1 as an overview of the process.

[1] These date ranges are not uniform because of the only limitation of using JSTOR: the publishers of *ESM* impose an embargo of two years, meaning that articles cannot be added to the JSTOR database until they are two or three years old. Even with this limitation, and because my goal of mapping *ESM* is to contrast the foci of *ESM* with the foci of *JRME*, this missing data is not prohibitive to my goal.

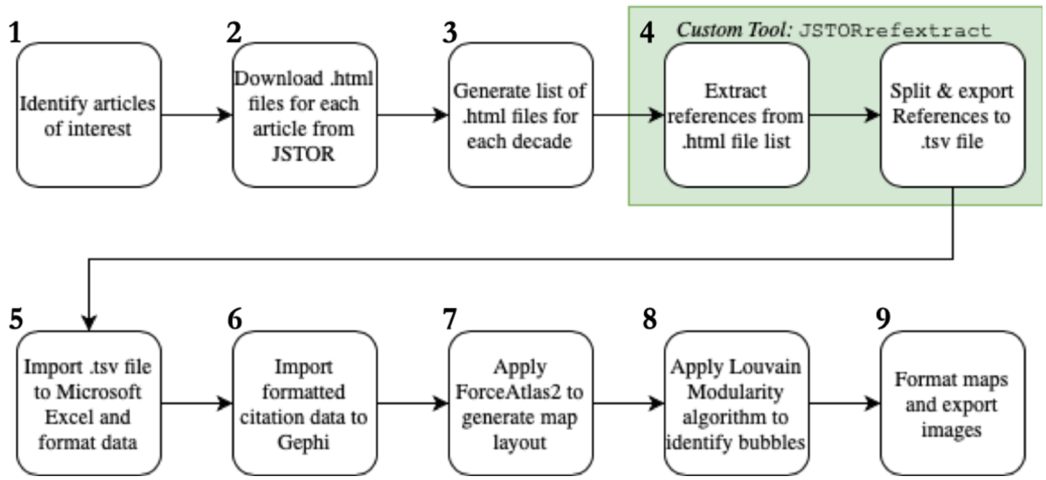


Figure 1. Process Flowchart From Webpage Download to Map Generation

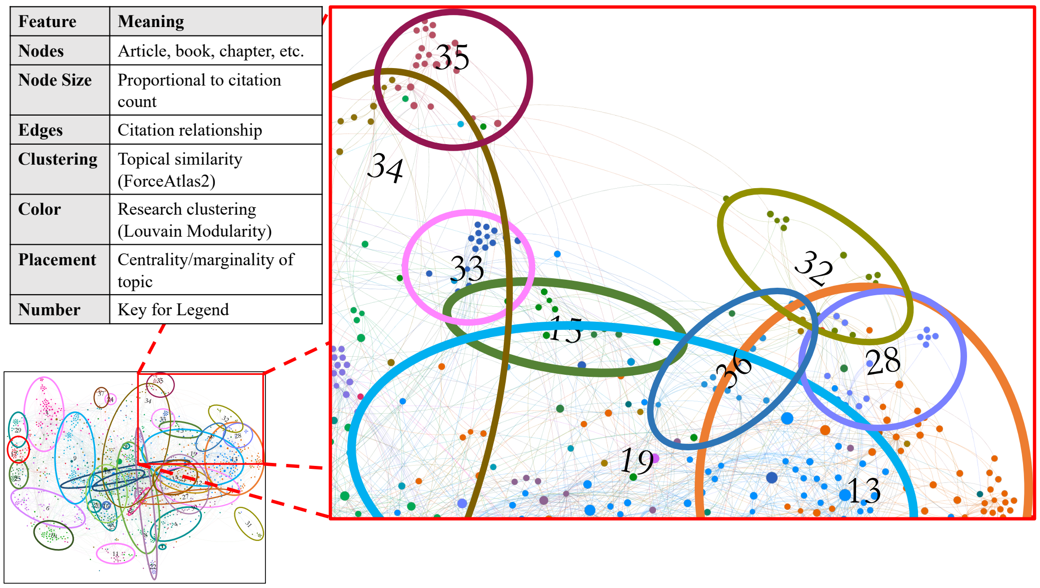
Algorithms for Citation Network Analysis

Placing the nodes and edges from a citation network onto a planar map, however, is not trivial. I leveraged an extant algorithm (ForceAtlas2; Jacomy et al., 2014) that interprets nodes as electrons and edges as extended springs. By simulating this physical system of electron repulsion and spring contraction, ForceAtlas2 runs until a stable state is found. The resulting map encodes the relationship between articles spatially. In the stable state, articles (nodes) that are close together are strongly connected by the articles that they cite, whereas those farther apart have fewer, or no, citations in common. In other words, in this state, topical similarity is encoded in spatial closeness (Noack, 2009).

To identify the conversation groups, then, I used a well-documented community finding algorithm (i.e., Louvain Modularity; Blondel et al, 2008) to find densely connected subsets of articles. These densely connected subsets correspond to the conversation groups within the field of mathematics education research. For example, consider the citation network showing the 1,500 nodes (articles, books, etc.) and 4,174 edges (citation relations) that comprise the 37 bubbles of research published in *JRME* in the 2010s that is inset into the lower-left corner of Figure 2.

The layout is the result of the ForceAtlas2 algorithm, and the circles are added and color-coded to denote the research "communities" identified by the Louvain Modularity algorithm. The circles are added later to provide a bird's-eye view of the clusters and their relative position within the map. Figure 2 provides additional detail on how to read the maps and lists the particular ways that information is encoded in the images.

It is important to note, however, that the Louvain Modularity algorithm merely identifies which nodes are clustered together; the process of naming the clusters is a second stage of analysis that is both quantitative and interpretive. Detailing the process of naming each bubble is beyond the scope of the present paper but is detailed in other work (Dubbs, 2021b). Having now discussed the method of analysis, I turn to theories of spatiality (Sloterdijk, 1998/2011, 1999/2014, 2004/2016), in general, and urban socio-spatiality (Larnell & Bullock, 2018), in particular, which undergird the reading and interpreting of the resulting maps.



Feature	Meaning
Nodes	Article, book, chapter, etc.
Node Size	Proportional to citation count
Edges	Citation relationship
Clustering	Topical similarity (ForceAtlas2)
Color	Research clustering (Louvain Modularity)
Placement	Centrality/marginality of topic
Number	Key for Legend

Figure 2. Sample Citation Network (*JRME* 2010s Foam With 1,500 Nodes, 4,174 Edges, and 37 Bubble of Research) With Enlarged Portion to Illustrate Key Features

2. Urban Bubbles and Foams: Theories of Spatiality, Continuity, and Disruptions

In this section I turn to work that has explicitly elaborated an understanding of "urban" that is socio-spatial. In other words, the framework unpacked here (Bullock & Larnell, 2015; Larnell & Bullock, 2018) considers "space as a social construction that is integral to social analysis" (Larnell & Bullock, 2018, p. 47). This so-called spatial-turn, then, provides a segue into a discussion of Sloterdijk's spatial project outlined in his Spheres trilogy (*Bubbles,* 1998/2011*; Globes,* 1999/2014*; Foams,* 2004/2016). Together, these ideas inform the present analysis by explicating a socially constructed spatiality wherein it is possible to imagine change. Furthermore, an explicit discussion of "urban" is necessary to provide clarity. As I have argued for mathematics education researchers to explicitly identify their understanding of "ethics" (Dubbs, 2020), I similarly argue here that it is necessary to clarify my understanding of urban, a polyphonic term with a range of specific and general meanings. I turn to that discussion of "urban" now.

Beyond Population Density and Demographics: A Socio-spatial Urban *Framework*

Departing from what they called urban-as-veiling, where "studies have used the label 'urban' as a proxy descriptor for poor, Black, and/or Brown populations" (Larnell & Bullock, 2018, p. 49), Larnell and Bullock outlined a three-dimensional framework for understanding "urban." The three axes of this framework include Significations of Urban, Spatial Logic of Urban, and Theory-Moments of Mathematics Education. I discuss each in turn.

First, Larnell and Bullock (2018; Bullock & Larnell, 2015) introduced the Significations of Urban axis. Along this axis are three competing significations, or meanings/understandings of urban: urban-as-sophistication, urban-as-pathological, and urban-as-authenticity. The first of these, urban-as-sophistication, draws on cosmopolitan narratives of urban centers as the pinnacle of human activity; this erases the systemic disenfranchisement of countless individuals. The second, urban-as-pathological, refers to any number of deficit discourses that frame urban spaces as lacking order, resources, and value. The third, urban-as-authenticity, rejects the externally ascribed meanings and instead centers the marginalized individuals in urban spaces and seeks to "[increase] their opportunities for success without undermining their cultural practices" (Larnell & Bullock, 2018, p. 52), recognizing that urban spaces have both resources and value.

Second, Larnell and Bullock (2018) introduced the Spatial Logic of Urban axis. Along this axis, there are four distinct spatial logics of urban: empirical-constructing space, interactive-connective space, image space, and place space. These four spatial logics correspond to Thrift's (2003) four conceptions of space. For Thrift, empirical-constructing space corresponds to the ways that a space can be measured (e.g., geographic boundary, demographics, etc.), while interactive-connective space focuses on "the pathways and networks that constitute space" (Larnell & Bullock, 2018, p. 48), such as social networks, roads, sidewalks, etc. Image space refers to the images associated with a particular space (e.g., graffiti, skyscrapers, etc.). Lastly, place space refers to the "everyday notions of spaces in which human beings reside" (p. 48). Together these four logics provide a layered understanding of space where layers of meaning intersect and overlap.

Third, Larnell and Bullock (2018) introduced the Theory-Moments of Mathematics Education axis. Although the first two dimensions conceive of "urban" in terms of its socio-spatiality, this final axis distinguishes between significant moments in mathematics education research: process-product, interpretivist-constructivist, social turn, and sociopolitical turn. For the authors, it is important to consider this axis because it moves the socio-spatial framework towards a mathematical-socio-spatial framework for space.

Beyond these three axes, Bullock and Larnell (2015) situated at the center the teacher(s)-student(s)-mathematics triangle (Cohen & Ball, 2000). This means that at any coordinate located within the signification, spatial, and theory-moment three-dimensional space must be understood as a place where "schooling," the interaction between teacher/s-learner/s-mathematics, is occurring. Furthermore, the teacher(s), learner(s), and mathematics triangle, in addition to being located at a coordinate within the framework, is situated within nesting ecological rings. To wit, urban schooling occurs within larger structures such as schooling systems, communities, and societies. Each of these ecological conditions necessarily influences the actual experience of schooling in urban spaces.

Looking back at this framework, it is clear that using a mathematical-socio-spatial concept of urban in mathematics education research will necessitate working across three axes, the learning triad, and nesting ecological spheres. This task is significantly more involved than drawing upon urban-as-veiling but is worthwhile due to the "contemporary, more complex, and ever-evolving notions of urban" (Larnell & Bullock, 2018, p. 44) that this framework elaborates. I return to this framework in Section 4 when I unpack the one bubble of research from the *JRME* map that includes "urban" in its title.

"Connected Isolations": People and Space as Bubbles and Foams

> Is space what *inside which* reside objects and subjects? Or is space one of the many connections made by objects and subjects? In the first tradition, if you empty the space of all entities there is something left: space. In the second, since entities engender their space (or rather their spaces) as they trudge along, if you take the entities out, nothing is left, especially space. (Latour, 2009, p. 142)

As Latour (2009) identifies above, there are at least two ways of viewing space: I refer to these as inside-space and engendered-space. In inside-space, mathematics education research is a space, a research field, that exists out there. This notion of inside-space reminds me of the "cocktail party" metaphor that I have heard used to describe the field of mathematics education research. In this metaphor, mathematics education research as a field is understood as a group of individuals mingling in a common space (we might call that salon "mathematics education research") and gathering into small groups, each having their own conversations (these conversations constitute different research foci). Only conversations near each other have any chance of overhearing one another. Within the cocktail party metaphor, our role as scholars is to distinguish the conversations from the cacophony, to listen to the conversation, then slip into the ongoing conversation (i.e., cite exiting research). This perspective, however, limits what we can do. We cannot step into a group and begin talking about something new; we need to join the conversation that is already happening. Furthermore, this salon can reach capacity. There may be a point at which no additional individuals may enter the salon/field unless another exits.

In contrast to this zero-sum inside-space, Sloterdijk (1998/2011, 1999/2014, 2004/2016) describes a theory through the metaphor of bubbles and foams, of engendered-space. Bubbles can be thought of as the "space of resonance between people" (Funcke, 2005, p. 28). As an alternative to the cocktail party metaphor, then, I propose that we consider, by way of analogue, the conversation groups of the cocktail party as the bubbles in Sloterdijk's theory. These bubbles are space, engendered by humans through their interaction, that "[gives] them meaning and [provides] them with a protective membrane" (Borch, 2009, p. 224).

To elaborate, the spaces in which people attain meaning are bubbles, and these bubbles constitute "microspherical worlds" (Borch, 2009, p. 226), each with their own rules for who is taken into account, who has a share in that micro-world, whose speech is classified as noise, and whose ideas are valued in that common world. We can, therefore, by naming the bubbles according to the research focus of the humans inside each bubble, understand how a particular bubble provides meaning and protection. For example, consider those researchers whose work is clustered within Bubble 19 of the JRME 2010s foam (See Table 1 and Figure 3 in Section 3) and center their work on equity and social justice. They are able to identify as "equity and social justice" mathematics education researchers. In particular, bubbles still capture that research activity is a fundamentally human activity, that researchers create space to discuss their ideas and assimilate additional humans into their micro-spherical worlds (Borch, 2009). Framing these research foci as bubbles, however, also emphasizes their fragility and the effort that must go into preserving the contingency of this space engendered by the people growing the bubble.

Significantly, bubbles are ontologically incommensurable from the inside-space of the salon because new bubbles may perpetually emerge and bubbles may expand ad infinitum; there is no limit to the size of the space of mathematics education research in engendered-space. Furthermore, there is no particular part of the foam whence new bubbles emerge: the foam is volatile per se. This endless potential for growth and change, therefore, has important implications for the foam, or conglomeration of bubbles that constitute the field of mathematics education research writ large. Further, the foam metaphor is helpful for a number of reasons.

First, the foam metaphor is helpful because, from afar, a foam looks like a solid object. From afar, mathematics education research seems like an ontologically solid object, something that is and has been fixed, inevitable, undeniable. Yet, from up close, we can see that the foam is comprised of many bubbles. Foams of bubbles "are fragile and protected by frail membranes, immunity maintenance is a crucial concern" (Borch, 2009, p. 232). Within the mathematics education context, these research bubbles are not fixed; they are volatile. It is necessary for those located within a particular research bubble to work towards maintaining the bubble's boundary because bubbles are cofragile; that is, if one bubble pops, the neighboring bubbles will be affected (Borch, 2009). Bubbles within a foam can burst, merge, and split; new bubbles can emerge.

Second, this metaphor enables us to consider the air conditions (Borch, 2009), the ambient conditions that permitted certain bubbles to emerge, merge, split, and pop. By naming the structures and discourses in mathematics education journals that permit some research foci to emerge, for others to grow in size and become more central within the foam, and yet others to remain on the margins before popping, this metaphor emphasizes the volatility of our field and permits us to name the specific conditions that fostered some research foci while stifling others.

Third, this metaphor, together with a Foucaultian reading of history, gives us an understanding of the field of mathematics education research wherein "it is easier for us to imagine that things might be different in the future" (Fendler, 2010, p. 42), as we no longer need to change the field as a whole, nor change the conversational inertia of groups of people, but rather split, burst, merge, or emerge. Rancière (2000) reminds us that our levers need not be large to accomplish change; we need not burst all the bubbles and we need not completely reconfigure the foam at once: "change is the result of a thousand creeping encroachments" (para. 8). I proceed in Section 3 with discussing the foams of JRME and ESM. From this macro-perspective, I then turn towards a critical reading of the maps in Section 4.

3. Other Foams: Maps of *JRME* and *ESM* in the 2010s

The purpose of this section is to introduce the bubbles that comprise the foams of mathematics education research as published in two journals: *JRME* and *ESM*. These journals were chosen because of their perceived quality (Nivens & Otten, 2017; Williams & Leatham, 2017) and the way that other scholars have used them as a proxy for the field of mathematics education research (Inglis & Foster, 2018). Because the full details of the method of data extraction, network analysis, and image generation are beyond the scope of this paper, what I detail here is a reading of these maps. My stance on truths is that there are multiple, and perhaps contradictory, readings that could be made with these maps. To elaborate, "in addition to my identity, the society in which I exist, the perspective whence I observe, the theories that I employ, and the data that I analyze each influence the conclusions I can draw, the knowledges I can produce" (Dubbs, 2021b, p. 4), and another reader will necessarily draw their own—likely different and potentially contradictory—conclusions from their own context.

JRME *in the 2010s*

Within the citation relationship data from the articles published in JRME in the 2010s, the Louvain Modularity algorithm, discussed in Section 1, identified 37 distinct bubbles of research. The names of these bubbles are listed in Table 1, and the relative position of these 37 bubbles within the foam of research published in JRME since 2010 is shown in Figure 3.

Table 1

List of the 37 Research Bubbles From the *JRME* 2010s Foam Together With Their Numerical Key Corresponding to the Locations Marked in Figure 3.

Key	Bubble Research Focus	Key	Bubble Research Focus
1	Proof and Argument	20	Math Achievement
2	Professional Development	21	Mathematics Identity
3	Children's Learning	22	Proof in RUME
4	Mathematical Discourse	23	Mathematics Teachers and Teaching
5	Schoenfeld	24	Empirical Statistics
6	Meaning of Equality	25	Algebra
7	Teaching's Influence on Learning	26	Problem Posing and Multiple Solutions
8	Proof and Reform	27	Racialized Mathematics Achievement Remediation
9	Mathematics Knowledge for Teaching	28	Qualitative Metasynthesis
10	Negative Numbers	29	Learning Disabilities
11	Limits and Calculus	30	Learning in Contexts
12	Culturally Relevant Mathe-matics African American & Indigenous	31	Research on Research
13	Racial Identity & Success	32	Gender and Achievement
14	English Language Learner's Identity & Participation	33	Urban Equity and Technology's Role
15	Achievement Gap	34	Sociological Perspectives on Learning
16	Sociocultural Learning	35	Psychological Studies & Repli-cation
17	Children's Achievement Intervention & Trajectories	36	Girls' Identities
18	Mathematics Curriculum	37	Research in Undergraduate Mathematics Education
19	Equity and Social Justice		

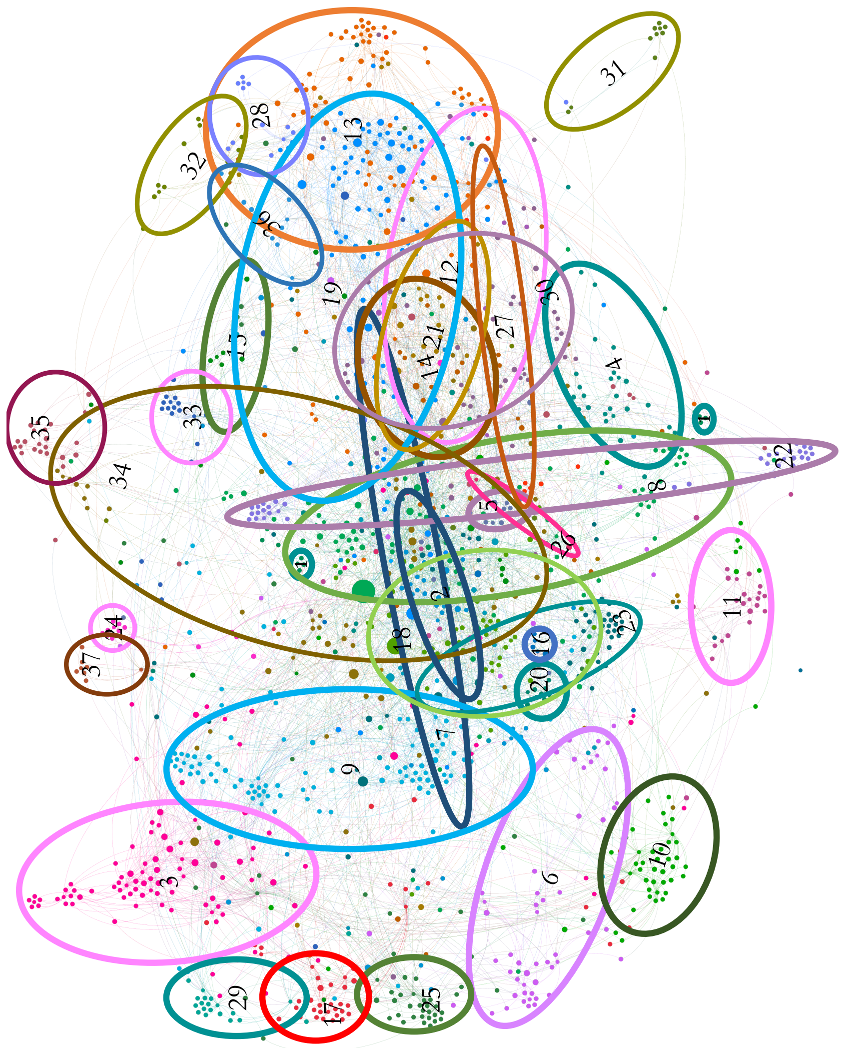


Figure 3. *JRME* 2010s Foam With 1,500 Nodes, 4,174 Edges, and 37 Bubbles of Research

Looking at the map in Figure 3, among the topics central to the research published in *JRME* during the 2010s are professional development of teachers' knowledge (Bubble 2), Schoenfeld's thinking and problem solving (Bubble 5), teaching's influence on learning (Bubble 7), proof and reform (Bubble 8, which includes the National Council of Teachers of Mathematics's 2000 *Principles and Standards for School Mathematics*), mathematics curriculum (Bubble 18, which includes the Common Core State Standards for Mathematics), and problem posing and multiple solutions (Bubble 26). Among the topics that are more marginal to the *JRME* 2010s foam are, clockwise from the top left, children's learning (Bubble 3), research in undergraduate mathematics education (Bubble 37), urban equity and technology's role

(Bubble 33), girls' identities (Bubble 36), qualitative metasyntheses (Bubble 28), racial identity and success (Bubble 13), research on research (Bubble 31, wherein I would situate the current study), children's achievement and intervention (Bubble 17), and learning disabilities (Bubble 29). This marginality/centrality analysis is but one type of reading that can be undertaken with these maps.

Another analysis could consider which bubbles have overlaps. I refer the reader to another study (i.e., Dubbs, 2021b) in which the overlap of the eight bubbles (see Figure 4) that can loosely be situated under the equity umbrella are discussed: (12) Culturally Relevant Mathematics African American & Indigenous, (13) Racial Identity & Success, (14) English Language Learners' Identity & Participation, (15) Achievement Gap, (19) Equity and Social Justice, (21) Mathematics Identity, (27) Racialized Mathematics Achievement Remediation, (28) Qualitative Metasynthesis, (32) Gender and Achievement, (33) Urban Equity and Technology's Role, and (36) Girls' Identities. Relevant to the present analysis, Bubble 33, Urban Equity and Technology's Role, will be unpacked and revisited in Section 4 (Reading the Maps).

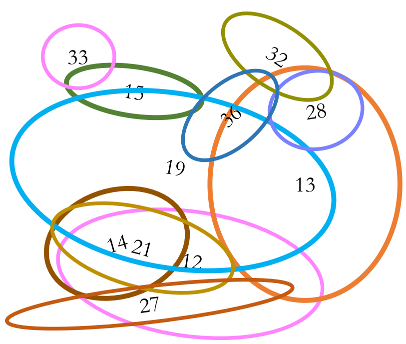


Figure 4. Subset of the *JRME* 2010s Foam Showing the Eleven Equity-Adjacent Bubbles

ESM *in the 2010s*

In contrast to the JRME 2010s foam, within the ESM 2010s foam, there are only eight bubbles: (1) Critical Theories and Philosophy of Mathematics Education, (2) Students' Learning of Concepts, (3) Students' Understanding of Concepts, (4) Teachers' Knowledge and the Teaching of Mathematics, (5) Proof and Argumentation, (6) Embodied Cognition and Mathematical Objects, (7) Mathematics Beyond the Classroom, and (8) Student Identity, Language, and Discourse. The relative position of these eight bubbles within the foam of research published in ESM since 2010 is shown in Figure 5.

Likewise, in contrast to the JRME foam, the bubbles in the ESM foam are much larger (in terms of the number of articles and citation links). As a result of there being fewer, larger bubbles, a few conclusions can be drawn about the foam of articles published by ESM. First, the articles published in ESM situate their work more broadly across the mathematics education research literature; in other words, the articles in JRME connect to and draw from very specialized literature bases within and outside mathematics education research while those in ESM, even when drawing on specialized literature bases, have more connections across the field.

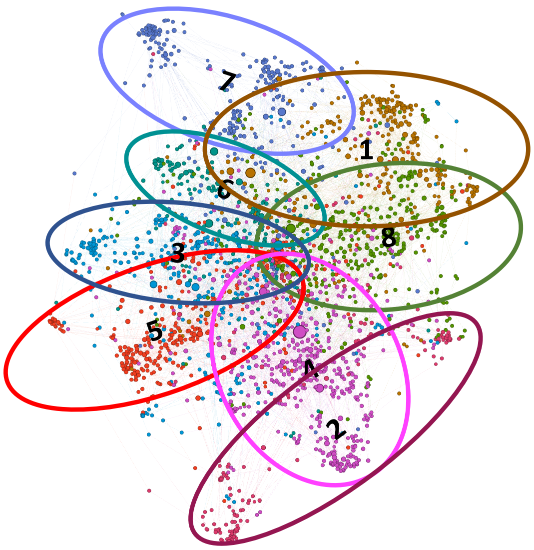


Figure 5. *ESM* 2010s Foam With 2,551 Nodes, 6,749 Edges, and 8 Bubbles of Research

An intuitive sense of this can be developed by revisiting Figure 5 and seeing the way that different colored nodes pepper the bubbles of which they are not a part.

Additionally, there is significantly less overlap of the bubbles in the *ESM* foam compared to the bubbles in the *JRME* foam. To elaborate, while Bubbles 3, 4, 5, 6, and 8 overlap slightly near the center of the map (near the location of the National Council of Teachers of Mathematics's 2000 *Principles and Standards for School Mathematics*), the bubbles are largely disjoint. This suggests that, while the bubbles are oriented around a central concern, they are largely distinct in the topics they address. However, unlike *JRME*, which has a considerable number of bubbles that consider equity, with the exception of Bubble 1 (Critical Theories and Philosophy of Mathematics Education), the bubbles in *ESM* orient around cognition, knowledge, and learning more narrowly than those approaches in *JRME*. The *urban* is notably missing.

4. Reading the Maps: Where's the Urban?

Looking across the 45 bubbles of research in these two foams shows the dearth of research on urban mathematics education in mathematics education research journals. Notably, the only bubble across the three journals to include "urban" in its name is Bubble 33 of *JRME*: Urban Equity and Technology's Role. It is important to look critically at the *JRME* articles within this bubble since "[*urban* education] serves as a safe proxy for discussing particular kinds of students without naming them" (Gutiérrez, 2008, emphasis original), where "urban" stands in for race, class, or other marked categories.

JRME *Bubble 33: Urban Equity and Technology's Role*

Figure 6 shows only those articles and citation links that fall entirely within Bubble 33. Here, we can immediately identify two articles published in *JRME* that anchor this bubble: the two articles by Kitchen and Berk (2016, 2017). Kitchen and Berk's pieces are part of a three-article exchange between Kitchen and Berk and Clements and Sarama (2017). Kitchen and Berk raised issues of inequity if technology, in general, and computer-assisted instruction (CAI), in particular, are painted as a panacea to the "problem" of urban[2] mathematics education. As can be seen in Figure 6, Kitchen and Berk's articles both connect to oft-cited authors in equity, urban education, and social justice such as Martin, Secada, and Tate and the Diversity in Mathematics Education Center for Learning and Teaching. In their words: "the concerns we highlighted in our commentary had to do with the delivery of CAI programs and potential misuses of them, particularly with regard to equity and access for underserved students, and not with specific features of CAI" (Kitchen & Berk, 2017).

In their response, however, Clements and Sarama (2017) focused on Kitchen and Berk's characterization of technology:

> Our critique addresses the following five issues: (a) a focus on the technology per se rather than the specific content and pedagogy of computer interventions, (b) generalization to all educational applications of computers after raising concerns about a restricted category of educational technology, (c) a false dichotomy of the goals of mathematics education, (d) a restricted view of teacher-based instruction and computer interventions as necessarily distinct, and (e) a restricted reporting of the research corpus. (pp. 474–475)

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[2] Using Larnell and Bullock's (2018) mathematical-socio-spatial urban framework, I unpack the meaning of "urban" construed by Kitchen and Berk (2016, 2017) in the next subsection.

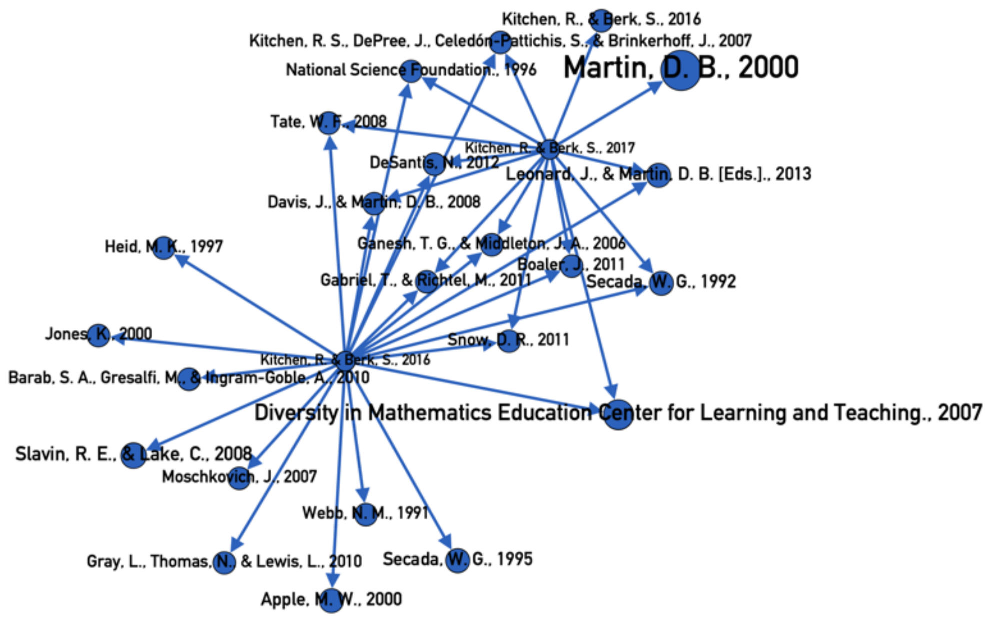

Figure 6. The Articles, References, and Citation Connections That Constitute Bubble 33 of the *JRME* Foam

This literal disconnect between Kitchen and Berk's aims and Clements and Sarama's critique is made explicit in Figure 7. In fact, Clement and Sarama's response article is placed by the Louvain Modularity algorithm in Bubble 17 (Children's Achievement, Intervention, and Trajectories) and is spatially located nearer to Bubble 17 than Bubble 33 by the force-directed algorithm (Figure 7 is not drawn to scale but is adjusted for readability; the actual distance between Bubbles 17 and 33 is much greater and is shown in Figure 3).

Looking critically at those references in common to both Kitchen and Berk (2016; 2017) and Clements and Sarama (2017) reveals an insightful pattern that justifies the placement of Clements and Sarama's piece (See Table 2 in the Appendix for a complete list of the nodes in Bubble 33 with the citing articles indicated). Each of the articles by Gray et al. (2010), Heid (1997), and Snow (2011) are about the technology in mathematics education, while Slavin and Lake (2008) discussed evidence-based practices in elementary mathematics. In other words, Clements and Sarama raised issue with the technological characterization given by Kitchen and Berk and situated their critique outside the issue of urban equity. This is further evidenced by the fact that the remaining references cited by Clements and Sarama are situated in Bubble 17 and not Bubble 33. The approach of Clements and Sarama's critique circles back to the "air conditions" of these foams: as a focus on *urban* mathematics education research diverges from the foci of other bubbles in the *JRM*E foam, the atmosphere is not particularly nurturing for these emergent bubbles.

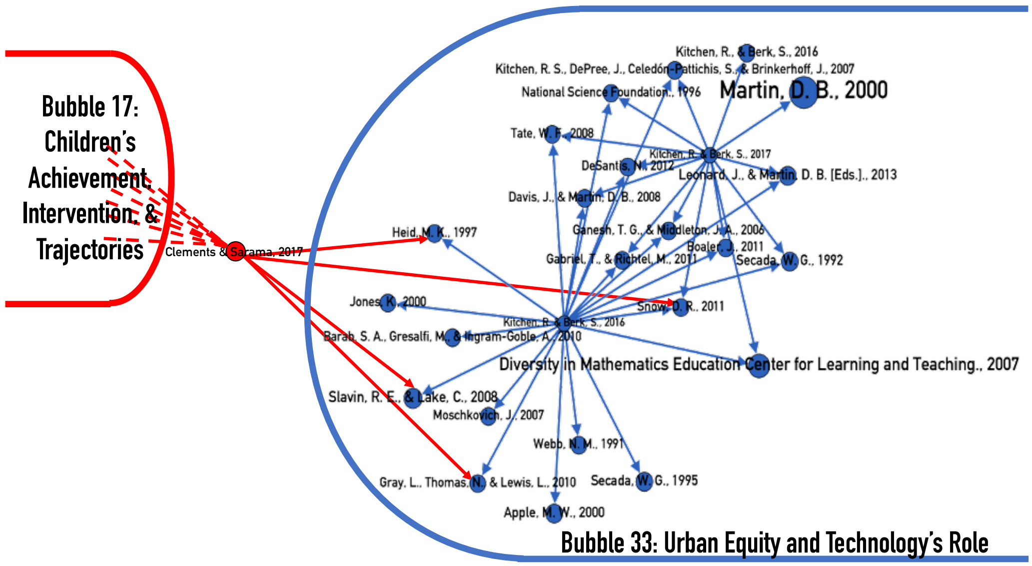

Figure 7. Bubbles 17 and 33 of the *JRME* 2010s Foam Showing the Location of Kitchen and Berk's Articles and Clements and Sarama's Article

Which Urban*? Reading the* Urban *Bubble With a Socio-Spatial Lens*

Having unpacked the topical focus of this bubble, I turn now to using Larnell and Bullock's (2018) Mathematical-Socio-Spatial Urban framework to interrogate which usage(s) of "urban" are present in Bubble 33. I proceed, in turn, through the spatial logics, significations, and theory-moments axes of Larnell and Bullock's framework before turning to discuss the ecological rings (schooling systems, communities, and societies). Each axis, as is shown next, is helpful for illuminating different rhetorical implications of the interaction between Kitchen and Berk (2016, 2017) and Clements and Sarama (2017), namely communication across significations, spatial logics, and theory-moments.

First, Kitchen and Berk (2016) firmly situated their concern—foreshadowing urban-as-pathology—with "improving the mathematics education of low-income students and culturally or linguistically diverse students who have historically been denied access to a high-quality and rigorous mathematics education in the United States…. both reinforced and compounded by geographic concentration" (pp. 3–6). In their response to Clements and Sarama's (2017) critique, the authors refined that their "goal was to raise equity-based concerns around the need for further research about CAI and its usage in Title I schools" (Kichen & Berk, 2017, p. 484). This focus on particular ways of defining and classifying urban spaces suggests the authors are drawing on urban as empirical-constructing space.

Second, Kitchen and Berk responded to both urban-as-sophistication and urban-as-pathology significations. First, the authors emphasized the urban-as-sophistication hope that pouring resources into underfunded urban spaces can transform them into the cosmopolitan ideal of urban as testament of human achievement. Second, with their "concern" discussed in the previous paragraph and emphasis on "low income," "underserved students," and "low academic expectations and lower pupil expenditures" (2016, p. 7), Kitchen and Berk contributed towards the urban-as-pathology discourse where urban spaces have problems that are to be fixed.

Third, Kitchen and Berk's (2016) commentary responded to each of interpretivist-constructivist, social turn, and sociopolitical turn theory-moments. Kitchen and Berk began by framing the research-proven benefits for CAI, which come from the interpretivist-constructivist moment. Then, the authors introduced competing research, from the social turn moment, that raises concerns if CAI eliminates opportunities for meaningful classroom discourse between students.

Lastly, Kitchen and Berk (2017) brought their critique into the sociopolitical moment by raising issues of power, funding, teacher preparation, societal discourses, etc. In contrast, Clements and Sarama's (2017) critique is grounded largely from the interpretivist-constructivist moment only. To illustrate, consider the critiques launched by Clements and Sarama (listed in the previous subsection) that focused on perceived limitations of Kitchen and Berk's description of CAI and a failure to account for teacher-chosen pedagogically driven use of CAI.

Additionally, Kitchen and Berk (2016, 2017) thoroughly considered the ecological rings of schooling systems and societies through their unpacking of policy that influences societal expectations for schools (e.g., No Child Left Behind legislation) and the realities of problematic implementation of CAI and scarcity of resources in underfunded schools. In contrast, Clements and Sarama (2017) responded primarily from the schooling system ring, particularly with their focus on the teacher-student-mathematics triangle; two of Clements and Sarama's critiques focus on teachers, content, and pedagogy.

5. Discussion and Implications

In this section, I discuss two implications for the field. The first, drawing on previous work in *JUME* by Bullock (2014), I elaborate the good, bad, and dangerous implications of urban mathematics education research's absence from the *ESM* 2010s foam and the marginal position that it occupies within the *JRME* 2010s foam. Second, I revisit the bubbles and foams metaphor to imagine the potential for the emergence of new foci and the constitution of a new foam in *JUME*. Together, these two discussions foreshadow a forthcoming citation network analysis of *JUME*.

On Ghettoes: Preservation or Marginalization?

One objective of this analysis is to show empirical evidence of the ghettoization of *urban* mathematics education research. According to Skovsmose and Penteado (2011), "Ghettoes in the classroom become created when differentiation turns into an us-them formulation, and labelling turns into a stigmatization. Many students find themselves located in such ghettoes." (p. 87). But, we, too, as researchers fall into our own us-them dichotomies that separate *us* and stigmatize *them* that fall outside our *us*: experimental vs. non-experimental research methods (Lester & Kerr, 1979), cognitivism vs. social constructivism (Kieren, 2000), disciplinary vs. equity research (Heid, 2010), equity vs. gap gazing (Gutiérrez, 2008; Lubienski, 2008; Lubienski & Gutiérrez, 2008), etc. Bullock (2014) named these dichotomies and separations the ghettoization of urban mathematics education research. Bullock, however, reminds us that Foucault cautioned, "my point is not that everything is bad, but that everything is dangerous, which is not exactly the same as bad. If everything is dangerous, then we always have something to do" (1983, pp. 231–232). The same goes for ghettoes in the mathematics education research community: there are bad, good, and dangerous functions of the ghettoization of research foci.

First, the ghettoization of urban mathematics education research is *bad* in the sense that it leaves existing structures and discourses (Foucault, 1969/1972) of mathematics education unchanged. It leaves unchanged existing structures that favor research on mathematics education in the narrowest sense and ghettoize sociopolitical analyses that challenge those same structures (Gutiérrez, 2013). Additionally, ghettoization serves the status quo because it enables existing structures to claim that urban mathematics education research is included even if its location is marginalized

Second, Stinson (2010), in an editorial, likened spaces like *JUME* and the Mathematics Education and Society Conference to the gay ghettoes of the 1980s. These ghettoes were self-chosen spaces in which the LGBTQ+ community could thrive; eschewing the expectations placed on the community by those outside, the LGBTQ+ individuals could engage in relationships and behaviors (e.g., drag; Muñoz, 1999) in ways that transgressed normative standards without fear of criticism. As a queer man, I can appreciate the freedom of a chosen ghetto, of a chosen community of like-minded—though neither uniform nor univocal—individuals. In this way, then, the ghettoization of *JUME* is *good* because it provides a place where research on urban equity, and other uniquely urban conditions, can be undertaken and presented. Furthermore, *JUME* provides a place for nuanced and layered analyses of "urban," such as the mathematical-socio-spatial urban framework provided by Bullock and Larnell (2015; Larnell & Bullock, 2018).

Last, it is the synthesis of the good and bad that suggests how *JUME* as a space, as a foam of distinct research bubbles, is *dangerous*. It is only on the conditions of *JUME*'s existence that much of the urban research can exist in published form. Yet, as a separate space, *JUME* leaves unchallenged the dominant discourses on what constitutes mathematics education research according to that research published in *JRME* and *ESM*. This is dangerous because "the more frequently certain ideas are produced in speech and writing, the more true they seem, and the less often certain ideas appear, the less possible they seem" (Parks & Schmeichel, 2012, p. 241). In other words, studying urban mathematics education seems more possible within the context of *JUME* than within the context of *JRME* and *ESM*. Nevertheless, we must remember that this is only how things *seem* to be and, indeed, we are *freer* than we feel (Foucault, 1988). It is this final notion of freedom and redefining what counts as mathematics education research that I discuss next.

Blowing Bubbles: JUME *as a New Distribution of the Sensible*

> While exhaled air usually vanishes without a trace, the breath encased in [bubbles] is granted a momentary afterlife. While the bubbles move through space, their creator is truly outside himself—with them and in them. In the orbs, his exhaled air has separated from him and is now preserved and carried further. (Sloterdijk, 1998/2011, p. 18)

> The distribution of the sensible refers to the implicit law governing the sensible order that parcels out places and forms of participation in a common world… a system of self-evident facts of perception based on the set horizons and modalities of what is visible and audible as well as what can be said, thought, made, or done. (Rancière, 2008/2009, p. 89)

Bubbles, as I have operationalized them in this research, each constitute contingent groupings of related research(ers) clustered around particular research foci. They embody our hopes for the field, the areas that we want to know more about, that we seek to understand. The bubbles that we as a collective blow form a foam, or collection of co-fragile, codependent bubbles. These bubbles together constitute a foam that outlines the scope of mathematics education research, that outlines a distribution of the sensible.

Rancière's (2008/2009) distribution of the sensible is "the system of self-evident facts of sense perception that simultaneously discloses the existence of something in common and the delimitations that define the respective parts and positions within it" (p. 12). In other words, a distribution of the sensible is a set of implicit guidelines that govern what we can see, say, or do as mathematics education research (the thing in common). It further indicates what is sensible: how the ways of doing, seeing, and saying fit together (parts and positions within it). Therefore, when we look at some article, book, or journal and decide if it is mathematics education research, if it fits within the coordinates that we use to determine if something makes sense as mathematics education research, we are simultaneously operating within and (re)defining a particular distribution of the sensible.

As each mathematics education research journal has its own aims and scope, these journal aims outline the expectations for topic, included content, acceptable theories and analyses, types of conclusions, etc. Together these outline a distribution of the sensible. As a result, "the distribution of the sensible reveals who can have a share in what is common to the community" (Rancière, 2000/2004, p. 12). Within *JRME*, many different foci/bubbles constitute the foam (with those closest to the aims of *JUME* on the margins). In contrast, within *ES*M, the bubbles that constitute the foam more closely outline disciplinary research. Yet neither of these foams include urban mathematics education research as a central focus. *JUME*, as another foam, therefore, is a space in which researchers that focus on urban mathematics education research can blow bubbles that would not flourish within the foams of *JRME* and *ESM*. As we remember that "change is the result of a thousand creeping encroachments" (Rancière, 2000, para. 8), may we hope that our foam begins to encroach on the others; that we, as a community, can breathe life into research that is not yet common within the foam of *JRME* and *ESM*. Doing so, we will reconfigure what we can see, say, and do in the name of (urban) mathematics education research.

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Appendix

Table 2. A List of the References Cited in Bubble 33 With the Citing Article Identified

Reference From Bubble	***Kitchen & Berk, 2016***	***Clements & Sarama, 2017***	***Kitchen & Berk, 2017***
Apple, M. W. (2000). *Official knowledge: Democratic education in a conservative age* (2nd ed.) Routledge.	X		X
Barab, S. A., Gresalfi, M., & Ingram-Goble, A. (2010). Transformational play: Using games to position person, content, and context. *Educational Researcher*.	X		
Boaler, J. (2011). Changing students' lives through the de-tracking of urban mathematics classrooms. *Journal of Urban Mathematics Education*.	X		X
Davis, J., & Martin, D. B. (2008). Racism, assessment, and instructional practices: Implications for mathematics teachers of African American students. *Journal of Urban Mathematics Education*.	X		X
DeSantis, N. (2012, March 18). A boom time for education start-ups: Despite recession investors see technology companies' "Internet moment." *The Chronicle of Higher Education*.	X		X
Diversity in Mathematics Education Center for Learning and Teaching. (2007). Culture, race, power, and mathematics education. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning.*	X		X
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Table 2. (cont.)

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