

Place-Based Mathematics Education: A Conflated Pedagogy?

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Place-based mathematics education (PBME) has the potential to engage students with the mathematics inherent in the local land, culture, and community. However, research has identified daunting barriers to this pedagogy, especially in abstract mathematics courses such as algebra and beyond. In this study, 15 graduates of a doctoral program in rural mathematics education were interviewed about their attempts to integrate PBME in their classrooms. By using qualitative methods to code and categorize interview data, three themes emerged: (a) PBME was easier to teach about than to practice, (b) several factors contributed to participants' level of depth and authenticity in employing PBME, and (c) teaching place-based statistics was fundamentally different than teaching place-based mathematics. The findings suggest that making a distinction between mathematics education and statistics education would benefit research and practice in place-based education as well as in related pedagogies.

The debate between local interests and national perspectives plays out on many stages, including that of mathematics education. The Common Core State Standards Initiative (CCSSI, 2010) laid the foundation for standardized academic goals across the country. The primary target of the Common Core resembles that of earlier systems of standards: rigorous mathematical understanding that is abstract enough to be extended to a wide range of careers and situations (CCSSI, 2010; National Council of Teachers of Mathematics, 2000), and that presumably serves national interests (Gutstein, 2010; Howley, in press). In contrast,

some rural educators argue that mathematical reasoning should emerge out of fluency with the mathematics of, and for, the local context (Bush, 2005). Mathematics teachers who care for place-based efforts, especially those in rural areas, are often caught in a tug of war between these extremes (Kannapel, 2000).

Place-based mathematics education (PBME) considers the unique history, geography, culture, and community of a place to be valuable resources for enhancing, and being enhanced by, students' learning of mathematics.¹ Among other reasons, teachers practice PBME to increase relevancy for their students and to help sustain the local place (Howley et al., 2011). In a cross-case analysis of exemplar PBME sites in seven states, Howley et al. (2011) found that attempts at PBME were plagued by constraints on time, limited resources, and dissonance resulting from unconventional pedagogy. Further jeopardizing the sustainability of PBME were doubts harbored by students, parents, administrators, and community members as to its effectiveness in increasing students' mathematical knowledge. A primary concern is whether PBME compromises the mathematical rigor

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¹ Although the mathematics of PBME is the same universally, the way in which the subject is approached is different from place to place.

demanded by state and national standards. Alternatively, from the perspective of teachers' seeking to sustain their local places, there is concern as to whether PBME that is taught in a mathematically rigorous way can maintain authenticity to place.

This article reports on a study conducted to investigate the sustainability of PBME. Since the empirical research literature on PBME is scant (Bush, 2005; Howley, Howley, & Huber, 2005), and because of the substantial challenges in practicing PBME, it is logical to contribute to the literature through use of extreme examples. Howley and her colleagues (2011) chose an extreme sample based on site reputation; this study used an extreme sample in terms of academic training. Fifteen mathematics educators who had graduated from a three-year doctoral program in rural mathematics education were interviewed. The challenges and successes they experienced in attempting to implement PBME were then analyzed for themes.

Related Literature

There is a dearth of empirical research on PBME (Bush, 2005; Howley et al., 2005). Thus, I begin by reviewing empirical studies on related pedagogies² and on place-based education in general.

Learning Methods and Perspectives Related to PBME

According to the Trends in International Mathematics and Science Study 1999 [TIMSS 1999] (Mullis et al., 2000) videotape analysis of mathematics classrooms across the United States, typical instruction consists of a teacher introducing material to students, followed by repeated examples (Stigler & Hiebert, 2004). There are exceptions. For example, in learning methods that are inquiry- or problem-based, students collaboratively investigate open-ended problems with reduced teacher guidance (Hmelo-Silver, Duncan, & Chinn, 2007; Savery, 2006). Hmelo-Silver et al. (2007) reviewed several studies on the effects of using these investigative methods in mathematics classes. On the whole, these studies suggested that inquiry- and problem-based methods in mathematics are roughly as effective as traditional methods for teaching procedural knowledge and provide significant advantages for solving multi-step problems. Hmelo-Silver and her colleagues also pointed out the empirical gains of investigative methods in softer skills such as self-guided learning, reasoning, and collaboration. Critics have cited studies suggesting that inquiry- and problem-based methods are too cognitively taxing to facilitate student learning, are disadvantageous to

low-level learners, and can have negative effects when there is insufficient scaffolding (Kirschner, Sweller, & Clark, 2006).

Other instructional perspectives position the mathematics classroom in a larger sociocultural context to underscore the value of all students. Examples include teaching mathematics for social justice (Gutstein, 2003), culturally-relevant teaching (Ladson-Billings, 1995; Tate, 1995), ethnomathematics (D'Ambrosio, 1985), and funds of knowledge for teaching (Gonzalez, Andrade, Civil, & Moll, 2001; Moll, Amanti, Neff, & Gonzalez, 1992). Although the methodology of PBME is often problem- or inquiry-based, it is driven by purposes more akin to those of the perspectives that value sociocultural awareness and action. Research has suggested that each of these perspectives—when functioning at its best—accomplishes the aims embedded in its name (Civil, 2007; Eglash, Bennett, O'Donnell, Jennings, & Cintorino, 2006; Gutstein, 2006). More commonly, these perspectives endure tensions of allegedly politicizing the classroom (Ravitch, 2005), frustration at the incompatibility of school mathematics and cultural aims (Civil, 2007), and self-doubt over unintended social outcomes (Bartell, 2013; Lubienski, 2000). It should be noted that these tensions are usually embraced as an inevitable part of approaching mathematics education critically. Despite many overlaps with other methods and perspectives, PBME distinguishes itself by rooting its basis squarely in local places.

The spirit of place-based education can be traced back as least as far as John Dewey's University of Chicago Laboratory Schools in the late 1800s (Grubb, 1996), but the term itself did not enter the research literature until the early 1980s. In his definitive piece on place-based education, Smith (2002) described five types of place-based education: cultural investigations, environmental education, problem solving of local issues, economic studies, and public policy involvement. Inspired by deep connections between the goals of place-based learning and critical theorists such as Freire, Gruenewald (2003) proposed a sixth strand, critical place-based pedagogy. However, this breadth of theoretical research on place-based education is somewhat deceptive as most of the documented cases have centered on solving local problems (Smith, 2002).

Benefits of PBE and PBME

Researchers and educators have provided rich accounts of the benefits of place-based education (PBE). Haas and Nachtigal (1998) discussed how PBE can increase students' quality of life through fostering relationships within their community and environment. Students may even increase their own awareness of place through PBE (Azano, 2011). Smith (2007) described how place-based activities have transformed the teacher-student relationship from a

² Several of these pedagogies could also be considered curricula; I choose to refer to them as pedagogies because of the primary role that teaching plays among the study's participants.

hierarchical structure to one of collaboration. In the same article, Smith provided examples of how PBE increases students' awareness of what is worth preserving in their local community and environment while at the same time equipping them with a sense of agency that they can make a difference in realizing this preservation. Takano, Higgins, and McLaughlin (2009) conducted a five-year follow-up study on a place-based initiative in Alaska designed to incorporate community values into the curriculum. They found that students involved in the program showed gains in confidence, academic skills, and connection with the community.

Similar benefits have been found, or at least hypothesized, to relate to place-based mathematics education (PBME). Lewicki (2000) arranged 100 days of place-based learning with 25 students in a Wisconsin high school. He found that, in addition to a more positive attitude and increased community accountability, the students improved their standardized mathematics scores by four grade levels in a single year. This was an atypical case; other reports of PBME do not necessarily cite increased test scores among the benefits (Howley et al., 2011; Smith, 2002). However, it should be noted that successful PBME implementation, as viewed by proponents of PBME, is often defined less by standardized test scores, and more with forging classroom-community relationships, motivating students with lessons that are relevant, and engaging students with mathematical ways of perceiving their immediate surroundings.

An archetype of PBME in the literature is that of Edgewater, an island school in Maine (Howley et al., 2011). The authors described Edgewater teachers as emphasizing place-based education at every grade level and in every discipline. Mathematics teachers at the school regularly engaged students in the past, present, and future of the island community. For example, one teacher covered patterns of oceanic flow to demonstrate how the island became populated centuries earlier. Another teacher supported students' investigation of the effects of pollution on clam populations around the island. A third teacher had students create mathematical models of a proposed school building, an activity that resulted in changing the orientation of the school when it was eventually built. Of the seven PBME exemplar sites in Howley et al.'s study (2011), Edgewater was an outlier. At all seven sites, students were engaged in innovative mathematics with links to the community, but aside from at Edgewater, PBME was notably absent in the algebra-to-calculus sequence of abstract mathematics courses (Howley et al., 2011). However, even though these seven sites were chosen as exemplars of PBME, perhaps the teachers of the abstract classes at these schools had not had

enough exposure to PBME theory. Thus, the first question examined by this study is, "How do mathematics educators with substantial exposure to the theory of place-based mathematics pedagogy transfer this theory into practice?"

Challenges for PBME

Amid the limited extant research literature on PBME are clues that suggest why it is so challenging to implement in upper-level mathematics classes. Bush (2005) posited that one of the most difficult yet important challenges for PBME is to engage in activities that maintain depth and authenticity. Depth refers to the degree to which a place-based activity reflects place. Authenticity is the measure of how accurately a place-based activity reflects a specific place. Studying the fractal patterns used to lay out African villages (Eglash, 1999) might be deep, but the authenticity would be dubious in a U.S. classroom. Conversely, modifying story problems to reflect the names of businesses and landmarks in the community might be authentic, but not deep. Since teachers more readily find examples of basic mathematics (e.g., arithmetic, proportional reasoning, geometric shapes) in the community, the unsuccessful struggle to find deep and authentic activities is often greatest for teachers of college-bound high school students (Howley et al., 2011). A third quality that becomes even more important in PBME at the secondary level is that of relevancy, or meaningfulness, to students (Smith, 2007). Even if a PBME activity authentically represents the local place in a deep way, the net impact on learning is questionable if the activity does not hold meaning for students. Since PBME activities that meet all three of these criteria would be valuable, the second question addressed by the study was, "What commonalities exist among mathematical activities that connect students with place in a deep, authentic, and meaningful way?"

Although these charges for depth, authenticity, and meaningfulness could, arguably, be extended to place-based pedagogy in any subject, there is an inherent feature of place that is particularly challenging for PBME: variability. In areas such as journalism, the distinctive aspects of a particular place fuel the subject content. The more that a local culture is divergent from the dominant culture, the richer the stories of that culture and that place become. The same is not true, however, in mathematics. The universal nature of abstract, standards-based mathematics and the peculiarities of distinct places suggest that the difficulties of engaging in PBME are inherent. This apparent conflict led to the third research question, "How do mathematics educators engage the tension between variability of local context and the universality of abstract mathematics?"

Methodology

Subjects were chosen from the population (N = 48) of former cohort members in a rural mathematics education doctoral program named ACCLAIM (Appalachian Collaborative Center for Learning, Assessment, and Instruction in Mathematics).³ The population had completed three years of doctoral-level coursework in which they had frequent contact with the theory of place-based mathematics education. An attempt was made to contact each of the cohort members by phone. Of the 48 members, 32 were successfully contacted. These 32 were asked four brief questions in a five-minute screening survey (current status in the doctoral program, current place of employment, the role rural places had played in their career, and willingness to participate in two interviews). All but one of the 32 expressed willingness to participate.

Guest, Bunce, and Johnson (2006) determined that a sample size of 12 was generally sufficient for data saturation in an interview-based qualitative study focused on a homogenous sample. Based on the following criteria and consultation with ACCLAIM leadership, this number was increased to 15 participants. Since the study was aimed at observing rural phenomena (Coladarci, 2007), priority was given to members who described rural places as playing a significant role in their careers. Participants were also chosen so as to provide diversity of geographic location (10 states were represented), biological sex (F=8, M=7), race (numbers suppressed to preserve confidentiality), and cohort (three from the first cohort, five from the second cohort, seven from the third cohort). At the time of the interviews, all the participants had passed their qualifying exams, and six had been awarded a doctoral degree. All participants were currently teaching either mathematics or mathematics education courses: six were teaching at a high school, five were teaching at a two-year postsecondary institution, and six were teaching at a four-year postsecondary institution (some participants were employed by more than one institution).

Instrument

Seidman (1998) recommended that interviews be conducted in three stages, with each round of questions probing more deeply. Given the relevancy of the topic to the participants' daily professional lives, they were eager to be interviewed and were assessed as not requiring three separate stages in order to reach the deepest level of internal reflection mentioned by Seidman. Thus, the participants were interviewed twice, with roughly one week between meetings. The first interview with each participant focused on past and present external experiences, while the second

interview focused on how the participants made meaning from those experiences. Both interviews were conducted in the spirit of Kvale and Brinkmann (2008), who described how interviews can create new knowledge for both researcher and participant.

The semistructured framework for the first interview (see Appendix) included questions such as, "How has your locale affected how you teach math?" and "What experiences do you have with place-based education?" Participants' answers to these questions informed the creation of a tailored set of second interview questions, crafted to elicit the most authentic answers from each participant. For example, in one first-round interview, a participant mentioned that he had used story problems but was not sure if that was sufficiently place-based. This moment of deliberation informed a second-round question for that participant of, "How do you decide what is an authentic integration of place and mathematics?" Sample questions from the second-round interviews are included in the Appendix.

Data Collection

Data were collected in the form of semistructured interviews, 27 by phone and 2 in person. With the exception of one participant who was able to complete only one interview due to scheduling constraints, each participant was interviewed twice. The interviews were all conducted within the space of two months and typically lasted about 45 minutes each (i.e., each participant was interviewed for a total of about 90 minutes).

Data Analysis

The interviews were audiorecorded, transcribed, and, using Atlas.ti software, coded according to a set of a priori and emergent codes. The a priori codes were selected based on research literature in areas such as mathematics education, rural education, and ethnographic research methodology. Emergent codes were formed throughout the interview process in conversation with new data and in situ analysis. This approach followed Strauss and Corbin's (1990) grounded theory approach. In total, 31 codes were formed. However, since some of these codes did not emerge until well into the coding process, the final list of 31 codes was used to code all of the interviews a second time.

After all of the interviews had been coded according to the final set of 31 codes, the researcher read all the quotes within each code. Juxtaposing quotes within a given code allows the researcher to identify commonalities and patterns within the code much more easily than can be seen from the initial sea of data (Guba, 1978).

Six main categories were constructed around participants' references to place-based pedagogy

³ See <https://sites.google.com/site/acclaimruralmath/Home>

(discussions, taking action, activities, examples, community connections, and program transformation). Multiple reports of the same instance were then recoded as a single instance. Aside from the cases of taking action, all the instances involved mathematics in some form. By reading through the quotes in these six categories, as well as the remainder of coded quotes related to participants' processing of place-based mathematics, three salient themes emerged. After the themes were synthesized, they were sent to all of the participants to ensure validity through a member check; two participants responded to this email, both stating that the results were a fair portrayal of their experiences. These themes are reported in the results section and are analyzed in the discussion section.

Results

Three major themes surfaced in analyzing the instances of place-based mathematics education: (a) PBME was easier to teach about than to practice, (b) several factors contributed to participants' level of depth and authenticity in PBME, and (c) teaching place-based statistics differed fundamentally from teaching place-based mathematics.

Participants referenced place-based pedagogy in a total of 76 unique instances (i.e., multiple references to the same instance were counted only once). The breakdown by type can be found in Table 1.

The prevalent form of engagement was through discussions, typically in the form of mathematics education professors' discussions of awareness of and sensitivity to place in their methods classes. The next most common way of engaging in place-based pedagogy was taking action in some form. "Actions" ranged from being conscious and sensitive about driving conditions for a student who drove in from the mountains to confronting issues of rural insensitivity at the institutional and state levels. Actions were the only

category where some instances did not involve mathematics directly. Least common were the attempts to transform an entire department towards a more place-centric educational environment. Community connections, such as inviting speakers into the class or taking the class on a field trip to a local farm, were also relatively rare. The final 29 instances of place-based pedagogy comprised activities (defined by taking up one or more class periods and designed to engage students at a deep level) and examples (brief examples or problems reflecting the local culture).

Although Table 1 gives an overview of place-based instances, it fails to capture the place-based awareness of participants. Table 2 provides a representative quote or paraphrase from each of the 15 participants on the topic of how he or she viewed rural mathematics education as distinct from mathematics education in general.

Teaching PBME vs. Teaching About PBME

Consistent with the findings of Howley et al. (2011), the majority of participants in this study found it difficult to practice PBME in mathematics courses at the algebra level and above. Participants reported a gap between the theory about which they had learned and their inability to achieve it in practice (to their satisfaction). As can be seen from the quotes in Table 2, there was a general sense that teaching mathematics should somehow be different in rural contexts. However, most participants were unsure of how to approach this difference beyond being aware of their students' backgrounds and using "rural-friendly" examples in instruction and testing. Ten of the 15 participants reported tensions from feeling that they should be doing more PBME. Of the other five, three felt that they were doing enough, and two did not consider PBME to be among their goals. The 10 participants who reported this tension fell into two groups: The first group felt that the grade level or content

Table 1
Participant Engagement in Place-Based Pedagogy

| Type | Instances |
|------------------------|-----------|
| Discussions | 21 |
| Taking action | 18 |
| Activities | 16 |
| Examples | 13 |
| Community connections | 6 |
| Program transformation | 2 |

Table 2
Participants' Views on How Teaching Mathematics Is Different in Rural Areas

| | |
|------------|--|
| Michael: | “After a lot of study..., there is no—well, I couldn’t find any, what I would call intrinsically rural math. But how I’ve tried to reconcile that ... is to [ask students], ‘What’s the purpose of your mathematics? How can you use mathematics to improve yourself or help your community and enhance either your personal fulfillment whether that be economic or not, or how does that help you improve your community to have your participating?’” |
| Elizabeth: | The approach to teaching should change “in an area where the tenants may not be in support of the students taking math”; people have “culture, background, and baggage and you have to take that into account.” |
| Joseph: | Urban and rural areas “offer different datasets” to work with in the classroom. |
| Larney: | The way you “frame questions” makes it “easier for one group than another.” |
| Stephanie: | My preservice teachers want to make math relevant to their kids' everyday lives, which to them are “not that different” in rural and urban areas. My teaching is “not necessarily rural based, but it is related to place and social justice issues.” |
| Derek: | Contexts have “to be specific to their goals”; “background is so important”; students come with a “history of understanding” their world and there is “no standardized math teaching that will fit everyone.” |
| Rebecca: | “Math is power” that “allows people to be successful wherever they are ... even if they are from rural areas.” |
| Lauren: | “I have to consider the context of where I am and where my students are coming from if I really want to be doing something.” |
| Juretta: | It’s important to “understand students' sense of place,” but “I’m not sure what rural education is, or if it exists.” |
| Kylie: | “People are different in different places” and you have to acknowledge that in your teaching. |
| Sandra: | The “kids who walk in your door are different day to day and class to class”; you must have different ways to reach them. |
| Heidi: | It is “absolutely different”; some rural kids cannot relate with public transport, CD stores, and similar urban phenomena. |
| Katie: | Math is the same “across cultures and history,” but how you teach students is different. |
| Ryan: | Math doesn’t “need a context,” but the teacher “must be aware” of the students' “social and cultural contexts” to relate with them. |
| Rob: | Students misbehave more because “there's not that much to do” in rural areas; teachers use rural schools as stepping stones. |

in the courses that they were teaching was not conducive to PBME, and the second group was simply unsure about how to implement PBME in a meaningful way.

Participants in the latter group felt that PBME would be well suited for their students but were unsure about how to implement it. This feeling persisted, even when the participants made attempts to incorporate place. For example, in her mathematics for elementary teachers course, Lauren had changed the content of story problems to reflect the local area. The following excerpt from an interview with her captures the uncertainties typical of the participants.

So I guess the thing for me is, is this word problem thing opening up the conversation enough or should more be done? ... I guess that’s the struggle.

What could you reasonably do and is it enough to have an impact? I guess that’s mainly it; is it just showing it in class, should there be some further work that they should do?

Other participants attributed their lack of engagement in PBME to inappropriate course content and presumed that they would practice more PBME in a different course (for one participant, this meant teaching in the K-12 setting; for the others, it meant teaching a methods course). When asked about the largest obstacles to practicing PBME, Larney responded:

Probably time vs. coverage would be a lot of it. Most of the folks that I do teach are—I don’t have

many education folks in my content courses—most are going into the physical sciences ... engineering, math, physics students.

Was the perception that PBME is more natural for education classes supported among the teachers of methods courses? Of the 15 participants, five had taught a university-level methods course for preservice teachers of mathematics. All five of these participants had discussed PBME with their students, either in terms of being aware of the cultural issues of a place or in terms of how teachers could position place as an affordance when teaching mathematics. However, these participants also reported experiencing the same types of difficulties with PBME in their content courses as the ten who were not teaching methods courses.

There were exceptions to this perceived difficulty. Kylie, one of the three participants who found it easy to integrate PBME, explained how she connected mathematics with place in her high school classroom:

[PBME deals with] things the kids are more familiar with so it actually hits home. We talk about all those word problems you probably remember from algebra class where you talked about the speed of the boat in still water; well, it's something they actually use here.

Comparing this quote with Lauren's question about whether word problems were "enough" raises the issue of depth.

Factors Contributing to Depth, Authenticity, and Meaningfulness of PBME

Participants rarely mentioned mathematical rigor when describing their engagement in PBME. On the surface, this finding is surprising because of research findings that have emphasized the difficulty in simultaneously maintaining mathematical rigor and an authentic connection with the community (Civil, 2007; Gutstein, 2003; Howley et al., 2011). This apparent contradiction can be explained with evidence that participants prioritized the integrity of the content in their mathematics classes above goals involving place. Stephanie said of PBME, "My first responsibility is to teach the math; I can't bring that interesting stuff in." Participants did, however, struggle with the depth and authenticity of their PBME, explicitly and implicitly.

When asked how she implemented PBME, Lauren paused and then tentatively listed out a few examples before confessing that she was "just fishing" and did not really know how to connect with place in an authentic way. She said, "There's a consciousness that's been raised by being in the ACCLAIM program, but the other part is the

implementation. How do you do it?" Michael echoed her concerns: "If [teaching math] is different in rural areas, then it what regard is it? And I don't have my ducks in a row on that one." Elizabeth questioned the criterion of depth. When asked about PBME, she immediately pointed out a discrepancy in definitions. She described herself as engaged in PBME as she defined it, but felt that the ACCLAIM staff would deem her version of PBME as not rigorous enough. Her approach to PBME was finding examples in the community that were relevant to the mathematics material being studied, and then incorporating these examples into her lessons.

Ryan problematized the situation further. He questioned whether depth and authenticity even mattered in PBME if the activities were not meaningful to students:

I really thought and struggled through the program because so much of rural mathematics education or place-based that I saw didn't seem like meaningful mathematics to me...; a lot of it can be statistical, but I definitely have a clear line in my mind between what's mathematics education and statistics education.

Ryan went on to question whether it was automatically meaningful to all rural students to calculate hay bale volumes, referring to a prototypical place-based mathematics problem from the ACCLAIM program. While casting doubt on the potential for meaningfulness of PBME, Ryan did express hope in teaching statistics in a meaningful way. Several other participants echoed his claim that statistics was the one area where they found it easy to incorporate place. In fact, of the 16 "PBME" activities described by participants, 12 dealt primarily with statistics. Moreover, the depth of connection with place was inherent in these activities by definition (as opposed to the 13 examples, which were more of a quick mention of, or tie-in with, the place).

Unlike with depth, there were insufficient data to discern with objective accuracy the authenticity of many of the activities. However, data from several of the interviews confirmed Bush's (2005) assertion that a teacher must have strong familiarity with a place in order to design authentic place-based activities. Juretta met regularly with the chamber of commerce, local legislators, and a small business startup center to collect information to design projects with her statistics class that would revitalize the town economy.

The recurrence of statistics throughout the interviews as a meaningful, deep, and possibly authentic way to engage in place-based pedagogy led to the third theme. This final theme examines differences between linking place with mathematical topics and with statistical topics.

Teaching Place-Based Mathematics vs. Teaching Place-Based Statistics

Several participants differentiated mathematics from statistics, underscoring the importance of nonmathematical components in statistics education. For example, to study economic disparities in the region, Joseph had collected data with his students. After fitting several mathematical models to the data, the students were unsure about how to choose the best one. Joseph informed his students, "It depends on the story you want to tell." Abstract mathematics brought the students only so far; the interpretation depended on the context of the data and the values of the students.

Participants appeared to leverage this dependence on context to immerse their students in the community. Juretta arranged for her class to meet with the committee of a local festival to discuss what data would prove helpful for local businesses. The class then designed a study based on surveys and interviews in order to gather the desired data. Since all these activities were vital to achieving statistical literacy, Juretta felt she achieved her instructional goals through, not in spite of, the place-based engagement. The same was not true of her mathematics classes, for which she had struggled to "work in" place-based activities. Joseph gave a similar account, stating that statistics seemed to "lend itself well to place-based education." He later described one of his core values as a professor as getting "the message out to the students that they can use mathematics as a powerful tool for change in the community," and then added, "Statistics is a good tool for doing that." Katie, who worked with students from multiple cultures, taught statistics and probability through traditional games from her students' cultures. Ryan described a statistical study on local drug use that had intrigued his high school students. He went on to assert that statistical studies, whether or not they were based in the local place, generally tended to be relevant to his students. He claimed that, despite an extensive search, he had not come across a single example of a PBME activity that would be mathematically rigorous yet meaningful to students.

Although place contributed to content in statistics classes, many participants viewed place-based activities as contradicting the course goals in mathematics classes. Michael reported that his colleagues in the mathematics department refused to teach place-based activities in their mathematics classes for fear of being marked down in evaluations (for not keeping pace with curricular goals). Sometimes these constraints were more self-imposed; Stephanie found PBME interesting but claimed that she would feel guilty indulging in it when there was so much mathematical content to cover. On the other hand, participants viewed using place-based examples in mathematics classes as desirable for conveying a concept and increasing motivation for students. Of the

13 examples of place-based pedagogy, 12 occurred in mathematics classes (as opposed to statistics classes). Thus, PBME was valued for its relevancy, but in small doses. When Derek, one of the three participants who reported integrating PBME seamlessly into instruction, was asked if it would be realistic to implement PBME at the high school level on a large scale, he replied with a chuckle, "It kind of depends on what the word 'realistic' means.... I guess I would say no, unless there's a major change in education overall." He went on to describe several ways that he had tried to advocate for PBME among his colleagues, before concluding that substantial PBME was a more likely fit for camp settings than for the current public education system. While many rural educators would welcome an education system more sympathetic to local communities, what can be done in the meantime? How can place-based efforts in mathematics classes resist a dominant culture that is intolerant of local efforts? The following discussion addresses these questions.

Discussion

In a refreshing piece that peered beneath layers of standards, learning objectives, and assessment, Noddings (2005) urged readers to ponder the deeper aims of education. There is little doubt that the participants in this study had indeed deliberated over such aims as they related to their local communities, land, sociocultural issues, and especially their students. Just as clear were the difficulties that arose as the participants tried to integrate these aims with mathematics education. Although participants viewed PBME as having the potential to integrate these aims, the majority did not feel that they were able to engage in PBME in a substantial way. Some attributed this perception to external circumstances such as their particular course load or time restrictions, while others cited their inability to decipher what it meant to incorporate PBME into their practice. Teaching about PBME in methods courses was easier for participants than implementing PBME. One explanation is that methods courses often cover topics such as cultural sensitivity, paving the way for discussions on PBME. Less obvious is the fact that the teachers of methods courses were generally working with pre-service elementary and middle school teachers, grade levels at which the mathematics is more readily intertwined with place (see Civil, 2007, for a candid account of the complexities involved even at the elementary school level).

The struggles voiced by teachers of upper-level mathematics content in teaching PBME supports prior findings that PBME is difficult to implement in higher-level mathematics classes (Howley et al., 2011). In the present study, however, participants had the benefit of substantial doctoral-level coursework related to PBME. If such a group,

with a collective average of roughly 20 years of educational practice and three years of theoretical background at the doctoral level, were largely unable to practice deep, authentic PBME in upper-level mathematics courses, serious consideration must be given to the feasibility of upper-level PBME. From a different perspective, does the content of upper-level mathematics courses serve the needs of rural communities? (See Howley, in press, for a convincing argument that it does not.)

Differences Between Mathematics and Statistics

There were exceptions to this content mismatch. For example, teachers found it relatively easy to teach statistical reasoning through place-based data. Place is a context and, as Cobb and Moore (1997) noted, “In mathematics, context obscures structure.... In data analysis, context provides meaning” (p. 803). In other words, mathematics teachers often use oversimplified real-world examples to illustrate an abstract concept, but the context is typically used as scaffolding; once the student grasps the abstraction, the context is quickly discarded (Cobb & Moore, 1997; delMas, 2004). This trend surfaced in the interview data where 12 of the 13 brief place-related examples arose in math, not statistics, classes.⁴ The context-rich PBME activities, however, were much more common in statistics classes, suggesting the conducive nature of the local data to the content of the statistics class. Not only is context *helpful* for learning statistics; several statistics educators have considered it indispensable (Vahey, Yarnall, Patton, Zalles, & Swan, 2006; Wild & Pfannkuch, 1999). Groth (2010) described two methods of teaching statistics that do not call heavily upon contexts but claimed that such methods sacrifice fidelity to the content. Caution should be exercised here because “context” carries numerous connotations. The context used in teaching statistics should involve actual data (Franklin et al., 2007) and preferably be relevant to the students (Gould, 2010).

The importance of context in statistics comes from its embedding of natural variability, the most crucial element that separates statistics from the mathematical realms of universal certainty. The same real-life variability that devalues applications in mathematics functions as core content in statistics (Wild & Pfannkuch, 1999). Cobb and Moore (1997) provided an example of using variability to investigate the historical events of a rural village over three

⁴ Clearly, high-level math is used in real-world applications. However, the modeling of these applications often involves variables that add substantial complexity. For math educators willing to invest the time and energy, such math modeling has much potential. Gutstein (2012a), for example, described his use of differential equations with high school students to model the spread of HIV/AIDS in the community.

centuries ago. They start with this set of numbers: (3, 5, 23, 37, 6, 8, 20, 22, 1, 3). Without knowing further information, these numbers are useless. We could take the mean, median, and mode, but we cannot know which one is most suitable. As it turns out, none of them is; the importance is in the variability. The numbers are the monthly totals of people accused of witchcraft in Salem, Massachusetts, in 1692. The first drop (from 37 to 6) can be attributed to the first time an accusation resulted in an execution, but what about the jump from 8 to 20 or the dramatic fall from 22 to 1? It is the conversation between the variation of the data and the context that breathe life into such analyses (Groth, 2007).

Due to statistics’ focus on variability, desirable qualities such as depth, authenticity, and meaningfulness arise naturally from standards-based content, rather than being appended to a set of abstract concepts. Simply put, the approach needed to study and implement PBME appears to be different from that needed for place-based statistics education (PBSE). The need to disengage this conflation of PBME and PBSE arises from the fact that statistics is not merely a branch of mathematics and is in fact fundamentally different from mathematics (Cobb & Moore, 1997; delMas, 2004; Franklin et al., 2007; Groth, 2007, 2010). Although statistics includes many mathematical components such as probability, it also emphasizes the importance of nonmathematical components (Groth, 2007) such as data collection design, data exploration, variation analysis, and interpretation of results—all of which depend on contexts beyond the mathematics (Franklin et al., 2007).

Beyond content differences, delMas (2004) described how mathematics and statistics require two separate types of reasoning. Mathematical reasoning centers on a level of certainty far removed from our experiences, while statistical reasoning emphasizes sensory input, regardless of how variable and uncertain it might be. Both types of reasoning are abstract, but they differ in their relation with context. Examples in mathematics tend to hinge on a specific quality of an object or relationship; the more background knowledge that is drawn in, the more it obscures the abstraction at which the analogy was aiming. In statistics, variability is the sum of a large range of factors, many of which are unknown. The more contextual knowledge is brought in, the more these factors can be unraveled to explain the variance. Not only does this association underscore why it is crucial to use authentic data in statistics education, it also explains why statistics could serve as fertile ground for pedagogies such as culturally-relevant teaching, funds of knowledge for teaching, and PBSE. Collectively, these pedagogies involve human relationships, culture, geography, environment, history, demographic trends, and patterns of injustice; because all of these areas comprise contexts rich in variability, statistical reasoning is essential for analyzing them in an authentic manner.

Achieving Deeper Educational Aims

The number of mathematics teachers at the secondary and the post-secondary levels is rapidly increasing (Boslaugh & Watters, 2008). Many of these teachers have had no training in statistics education and are unsure of how to teach statistics (Groth, 2007). For these teachers in particular, place-based statistics appears to be a relevant and rigorous pedagogical option. Just as several participants in this study discovered statistics classes to be well suited for developing relationships between their students and the local place, teachers can leverage the context-friendly nature of statistics to achieve deeper aims of equity, cultural relevance, and community involvement. Similarly encouraging is the finding that several participants were able to integrate discussions on PBME seamlessly into methods courses for preservice teachers.

The lingering question is, “How can teachers accomplish deeper educational aims, such as PBME, in algebra-to-calculus mathematics content courses?” One solution proposed by Gutstein (2012b) is to “dance” between two distinct sets of goals—one related to content and the other to social justice aims—with the understanding that one set of goals will frequently get trumped by the other. This method would likely be perceived as risky by teachers who are nervous about high stakes assessments, but it is certainly one way to ensure that deeper aims are addressed. A second option, which can facilitate the goal-dancing, is to integrate statistics or applied mathematics into the mathematics curriculum (Leonard, 2010). One integrative activity was reported in this study: Joseph plotted local economic data and then had students attempt to fit the data points with various curves. Such activities, while perhaps more difficult to orchestrate, offer students the combined power of mathematical tools with context-friendly statistics. Moreover, in the present study, three participants were able to achieve their PBME aims in mathematics content courses out of devotion to and intimate awareness of (a) their place, (b) their students, and (c) the mathematics. Although the connections they reported making were mostly examples that lacked the depth for which Bush (2005) called, they were able to leverage students’ knowledge of their place as an asset for better understanding abstract mathematical concepts.

Concluding Remarks

In the teaching of algebra-to-calculus mathematics, the deep use of contexts such as a local place is in tension with standards-based objectives; in the teaching of statistics, the use of contexts is indispensable for understanding the process of statistical investigation. Educators and researchers who are devoted to the context of place should be aware

of this distinction and strategize accordingly. Place-based mathematics education is in dire need of exemplars⁵ who integrate culture, land, and community with content in the algebra-to-calculus sequence; ways must be then found for educators to be inspired by these exemplars. Place-based statistics education, in contrast, is facilitated by Web data, the rapidly increasing number of statistics classes, and the synergy of statistics content with rural purpose. Conditions are ripe for place-based statistics education to spread as a new area of research and practice. Through conjoined efforts within the two distinct pedagogies, we can better accomplish their intersecting aim of sustaining rural places.

⁵ Exemplars include Ron Eglash and his colleagues. Eglash et al. (2006) have created a set of “culturally situated design tools” (<http://csdt.rpi.edu>) that engage students in ethnomathematics through exploring traditions of African, African American, Native American, and Latino cultures. The level of mathematics within the tools ranges from elementary to well beyond the typical high school level.

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Appendix: Semi-structured Interview Protocols**Interview 1: History with Rural Mathematics Education (Selected Questions)**

1. Tell me about your experiences with rural mathematics education before joining ACCLAIM.
2. As an ACCLAIM student, how were you exposed to rural education issues?
3. How has your locale affected how you teach mathematics or mathematics education classes?
4. What experiences do you have with place-based education?
5. What external challenges have you faced in relating mathematics with rural education?
6. How would you describe your current intellectual project?

Interview 2: Making Meaning of the Experiences (Sampling of Typical Questions)

1. What is your definition of rural? (What are the common factors between these seemingly different areas?)
2. How do you understand the role that rural plays in mathematics education?
3. How has this view of rural math education changed from when you first entered ACCLAIM?
4. What internal struggles have you faced in attempting to relate mathematics with rural education?
5. When you use context in a class, how do you choose which culture to appeal to?
6. Would you consider yourself a stronger supporter of rural mathematics education in general, or of the specific department in which you work?
7. How would you respond to someone who sees that your PhD is in rural mathematics education and says, “Hey, math is math; it’s the same anywhere. There shouldn’t be any difference in teaching math in New York City or at Rural Place High School...”?
8. What life values are most important for you to convey to your math students?