At the Intersection of Classroom Culture and Culturally Relevant Pedagogy: What Students' Arguments Around Maps Reveal About How to Increase Student Achievement Within Our Diverse Society

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This paper describes data from the Community Mapping Project (CMP), a set of activities within a summer seminar for high school students. CMP was designed based on the principles of culturally relevant pedagogy to create conditions where students would appropriate statistics as a tool for identifying and describing inequities that face their communities. An analysis of pre- and post- assessments revealed measurable improvement in the students' statistics understanding. However, fine-grained analysis of the classroom video revealed several tensions that arose between the three social justice goals of the curriculum and the instructional objective of learning statistics. This paper uses activity theory as a lens to identify and describe these tensions.

INTRODUCTION

The statistics education community has not yet emphasized how to improve achievement of traditionally underserved and marginalized students. While major strides have been made towards understanding many complex issues facing our schools, fundamental pedagogic changes at the classroom level have yet to materialize. This paper reports the findings of the Community Mapping Project (CMP) carried out in Los Angles, and informed by principles of Culturally Relevant Pedagogy (Ladson-Billings, 1995). The goal was to create conditions under which students themselves would come to recognize how statistical concepts are relevant to issues of equity for learners coming to school from low-income and minority communities. The project resonated with the three principles laid out in Ladson-Billing's framework— 1) a sociopolitical or critical consciousness, 2) a willingness to nurture and support cultural competence, and 3) an ability to develop students academically (Ladson-Billings, 1995). As our analysis revealed however, potential tensions can arise between the social justice goals and academic statistical goals during the teaching and learning of culturally relevant statistics—describing these tensions and their influence on learning statistics is the topic of this paper. Activity theory, as a tool for identifying and examining these tensions also provides suggestions about how to anticipate and avoid such tensions in future designs.

Critique of Social Inequities

Critiquing social inequities involves developing intellectual habits and perspectives which question and challenge policies and practices by schools and/or other institutions. To help directly connect quantitative information and statistical analyses to social justice issues facing their community the students learned how to use a Geographic Information System (GIS) called MyWorld (Edelson, Brown, Gordin, and Griffin, 1999). GIS are software applications that support visualizations and interactive maps using

color, shape, size and other visual attributes to represent data values that have specific locations on the map. The visual representation of data on a map depicting a familiar location mediated between the students' personal knowledge of their own communities and the quantitative data that we wanted them to recognize as a tool for supporting their arguments.

Nurturing and Supporting Cultural Competence

One way to nurture and support cultural competence is by focusing on developing community membership and pride. This project attempted to foster community membership and pride by tapping into students' knowledge about their own communities to encourage student discourse. The hope was that these connections to students' own communities would help them develop academic identities while retaining their cultural identity. Developing a positive academic identity is related to academic success (Mehan, Villanueva, Hubbard, Lintz, and et al., 1996), provides a framework that helps students construe the meaning of their school experiences in positive ways (Franquiz and del Carmen Salazar, 2004) and construct an ideal student that they want to grow into.

Developing Students Academically

Given the opportunities in our present society that are contingent on academic success, one of the most important principles of culturally relevant pedagogy is to provide students with all the skills necessary for them to succeed in school and other institutional settings as those institutions exist today. For the current analysis, academic success is equated with learning the key ideas of statistics and developing a robust sense of how to reason and argue with quantitative data.

CONCEPTUAL DIFFICULTIES WITH STATISTICS LEARNING

Statistics is clearly one of the most transparently relevant mathematical topics taught in school. Understanding statistics allows students to make more informed decisions about everything from health care to politics. As such, it is a major thread of the mathematics curricula in the United States. The statistical goals of our project were designed to be consistent with the recommendations of the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (2000) and the California Mathematics Frameworks (1999). The instructional design of the project also drew on literature addressing conceptual difficulties with statistical learning. Statistics can be a difficult subject to learn because of the pre-existing, intuitive ways people have of working with and reasoning from data.

There are at least three relevant difficulties that high school students have when reasoning with and from data. First, students have difficulty generalizing from data. One of the most consistent findings from the literature about statistical reasoning is that students have difficulty with reasoning about the aggregate and generalizing from data. Instead, students are much more inclined to reason from individual, meaningful data points (Konold and Higgins, 2002). This was one of the tensions we had identified prior to our study and which CMP was designed to address. Second, students' intuitive understanding of central tendency are at odds with some of the procedures used to calculate the mean. Similar to the points made above, students intuitively conceptualize

the central tendency of a set in terms of a representative, individual data point. As a result, they have trouble reasoning about the group as a collective when the central tendency has no concrete correspondence to a data point (Hancock, Kaput, and Goldsmith, 1992). GIS maps were chosen as the main tool for our project because they offer an effective and compelling way to visualize distributions organized by their location. Third, when drawing inference about co-variation between variables, students often focus exclusively on one aspect of the data. For example, a study by (Batanero, Estepa, Godino, and Green, 1996) found that, when faced with a contingency table about the relationship between smoking and Bronchial disease, 70% of a sample of 200 high school seniors were unable to draw a statistically valid conclusion. The most common error was to only attend to part of the contingency table. Other studies have found that students and adults have difficulty in interpreting scatter plots (Noss, Pozzi, and Hoyles, 1999).

For our project three different sets of goals guided our design activities, often suggesting somewhat different approaches to designing the classroom activities. One goal was our intention of aligning our instructional objectives and assessments in ways that matched the mathematics standards. Another aspect guiding our design was what we knew about students' conceptual difficulties with statistical reasoning. Finally, our project had a commitment to having the statistical activities and discussions driven by the students and their perceptions of the need, relevance, and value of statistical reasoning to their larger social justice agenda. As we will demonstrate, the academic goals and the goals of cultural relevancy did not always align and we often had to negotiate a path between the two.

THE STUDY

In what follows we describe data from the Community Mapping Project (CMP), a summer seminar for high school students, designed by UCLA's Institute for Democracy, Education and Access (IDEA). The IDEA summer seminars have been offered for the last several years and provide AP social studies credit for students who enroll and carry out social science research around a common theme. For this particular seminar, the theme was the 50th anniversary of Brown v. Board of Education—the US Supreme Court case that desegregated US Schools— exploring issues of educational access across Los Angeles over the past five decades. Seminar participants were 30 twelfth grade students recruited from underprivileged schools in the Los Angeles area. Five parent advocates, six urban teachers, eight undergraduate students, five graduate students and three educational researchers also participated.

Los Angeles, like many other metropolises, has developed into many relatively racially homogenous neighborhoods. In Los Angeles these neighborhoods are geographically specific and racial boundaries are often well correlated with socio-economic factors (e.g., income, housing prices etc.). For example, the central and eastern areas of Los Angeles are dominantly Latino; the neighborhood of South Central is predominantly African American; and the coastal regions are predominantly Caucasian. Income levels are generally greater along the coast. Homogeneous neighborhoods such as these lead to de facto segregation in the schools. Even though there are voluntary bussing programs, it is not uncommon to find neighborhood schools that are completely Latino.

In Los Angeles, these demographic trends are exacerbated by an inequitable distribution of resources within the school system, which has left some schools without textbooks or with dilapidated campuses.

Over the course of five weeks, students examined the struggles of different communities for decent schools through readings in sociology and conducted an oral history project by interviewing community members, activists, and fellow youth. Students also used data from the California Department of Education and United States census to create GIS maps (Figure 1) depicting the transformation of social space in Los Angeles and its relationship to the conditions in Los Angeles-area schools today. At the end of the seminar, the students presented their research in a public forum at UCLA. The analyses of this paper are limited to only those parts of the seminar connected to statistical reasoning using GIS.

The students were organized into five working groups with each group specializing in a particular decade for their group's oral history project and GIS investigation. Students used data from the California department of education spanning from 1950-2000 (www.cde.ca.gov). However, because data collection practice changed over the five decades that the students were investigating, the groups had access to slightly different data sets. For this reason, for our case studies we followed two groups studying the 1990s and 2000s, because both those groups had similar data as well as the most complete data sets. The amount of time devoted to the GIS inquiry and quantitative inference is difficult to calculate. Of the 25 days of the seminar, 11 days included at least 1 hour devoted exclusively to GIS activities, with substantially more time being devoted to the GIS activities as the seminar came to an end and student final presentations came closer.

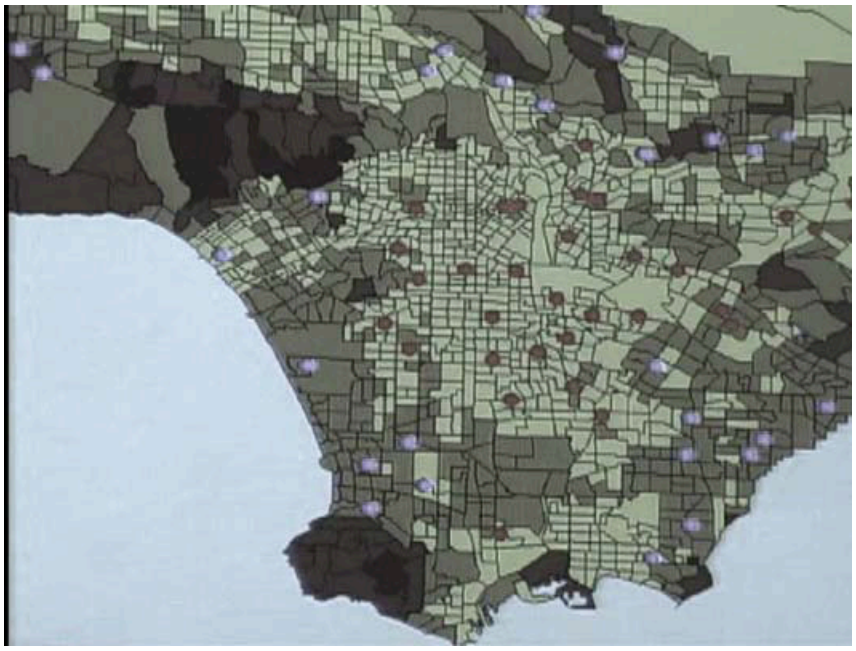

Figure 1: Student GIS map of Los Angeles showing income (darker shows higher level) and graduation rates (light dots show schools with high graduation)

DATA AND METHODS

The data analyzed for this study included pre- and post-assessments, video recordings of two case study groups during the GIS activities and student's final presentations. The tests and final projects were used to assess the students' statistics learning. The video case studies were analyzed qualitatively to illuminate tensions that arose between this instantiation of a culturally relevant pedagogy and the project's statistical objectives.

- *Written Assessments*: The pre-/post-assessments consisted of 4 questions derived from a clinical interview designed by (Konold et al., 2002). Both tests were designed with exactly the same data as Konold's (ibid.) interview but the original problem context was modified to make it relevant to issues of social justice. For example, one question states:

  > A researcher interested in the forced eviction of the citizens of Chavez ravine to build Dodger Stadium suggests looking at how much it costs to buy a house in each neighborhood at that time. He finds information about house prices on a small group of people from both neighborhoods. Table 1 shows in
  > formation about 51 Chavez Ravine residents and the price of their houses in thousands of dollars. Table 2 shows information about 79 Pasadena residents and the price of their houses in thousands of dollars. Looking at this data, what do you now think about the researcher's reasoning that 'residents were forced out of the Chavez Ravine neighborhood because they were poor.' What exactly about the data makes you think this?

- *Oral Presentations*: Using a similar rubric to that of the pre- and post-tests, we also analyzed the final presentations in terms of the arguments the students develop and the way in which they use statistics and the GIS maps as evidence. For example, the following statement by a student was coded as a claim about a relationship between two variables, using aggregate evidence, but in a qualitative way:

  > This map is the graduation rate from 1986. The blue dots are more than 70% of the students that graduate that is around the high income. The red are the less than 30 % of graduation rates. As you can see in the low median income—so, you can really tell that they have more credentialed teachers.

- *Video Analysis:* All of the video recordings of the two case study groups were watched and logged for statistical talk and activity. Cases were chosen for this paper to illustrate the emergent tensions between the culturally relevant pedagogy goals and the statistical pedagogy goals.

THE EXPANDED METIATIONAL TRIANGLE AS AN ANALYTIC TOOL

Preliminary analysis of the video record, as well as our own observations during the course of the study, identified that there were tensions between the different pedagogical goals of the CMP. Therefore, we conducted a secondary analysis of the video record using the expanded mediational triangle (Engestrom, 1987) as a heuristic for identifying and examining the way in which the activity system influenced the students' individual work and ideas. The expanded mediational triangle (EMT) was chosen because it has often been used to successfully identify and resolve "contradictions" within the system being observed (c.f., Engestrom, 1990a; Engestrom, 1990b, 1991). The EMT is a representation (see Figure 2) designed to capture the interconnected nature

of human activity by identifying the individual or subject participating within the activity, and the 5 key mediators of the individual's activity. Briefly, those mediators begin with the physical (e.g., GIS software) and conceptual (e.g. statistics as a discipline) artifacts, that the individual uses to accomplish their object or goal (Cole, 1996; Cole & Engestrom, 1993). The individual and the community in which they reside share this object. As we will demonstrate below, there were several objects of activity for the CMP that emerged from the two sets of pedagogical goals.

One the individual, tools, community, and object are identified, the therefore further specifiess the rules which the members of the community follow in pursuing their shared object, and the division of labor by which they organize themselves (or are organized by others). Figure 2 summarizes the activity system that we had envisioned as a desired outcome when beginning the CMP project. Note that the object that we hoped the students would pursue was one of producing a convincing claim about the state of educational equity in Los Angeles. We believed that this would in turn lead to the outcome of students developing and appropriating the knowledge, procedures, and concepts of statistics that they had employed in arguing for this claim. As we will discuss below, contradictions arose in the design of this classroom activity system, which we believe constrained the effectiveness of the statistics component of the curriculum design.

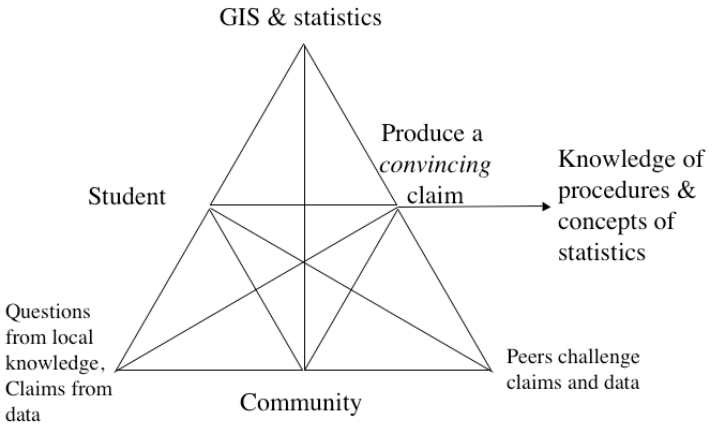

Figure 2: Imagined Activity System for Math Through Argumentation[1]

FINDINGS

Analyses of the written assessments showed a rise from 7 to 10.6 from pre-test to post-test, an average gain of 3.6 points. This gain was statistically significant ($t=5.364$, $p<.005$), and demonstrated modest advances in the ways that students were making inferences based on data. However, these modest gains are not representative of all the students' statistical activities during the seminar. During the seminar they used a number of statistical concepts that were not measured by our assessments. Overall, analysis of the

[1] Please note that all of the activity triangle diagrams were adapted from Engestrom, 1993.

written assessments revealed that students' experiences with GIS to investigate social justice issues seemed to have increased their perceived value of quantitative data which was evidenced in certain circumstances where students made the shift towards using aggregate measures rather than generalizing from individually meaningful data points.

In the final oral presentations there were a total of 135 claims, about one fifth of which (25) were based around GIS maps. The mean number of claims per group was 20.6 with a range from 18 to 30. We noted that the largest group was claims made with no evidence at all. This prompted a closer examination of our coding scheme, which revealed that we did not distinguish between types of claims and evidence. We eliminated from our analysis the cases of unsupported claims and reanalyzed the oral presentations against types of claims and evidence, as well as the context in which these claims were made —with or without GIS maps. Although we had predicted that that the GIS context would help students make more sophisticated claims using quantitative evidence, this was not supported by our data. The only time where students seemed to utilize more sophisticated statistical evidence in conjunction with GIS maps was when they described a single variable.

Tensions in the Curriculum

In order to understand both the reasons that the curriculum was successful, and the reasons that it fell short of our expectations for helping students to appropriate the tool of statistics as a way of making convincing claims, we examined the video data of the case-study groups at work. This analysis demonstrated a tension between the statistical goals and culturally relevant goals of the project. Figure 3 illustrates the advocacy-oriented activity system that emerged with respect to the culturally relevant goals of the project, while Figure 4 highlights several of the key contradictions that we identified between the imagined statistical activity system (Figure 2) and the advocacy-oriented activity system.

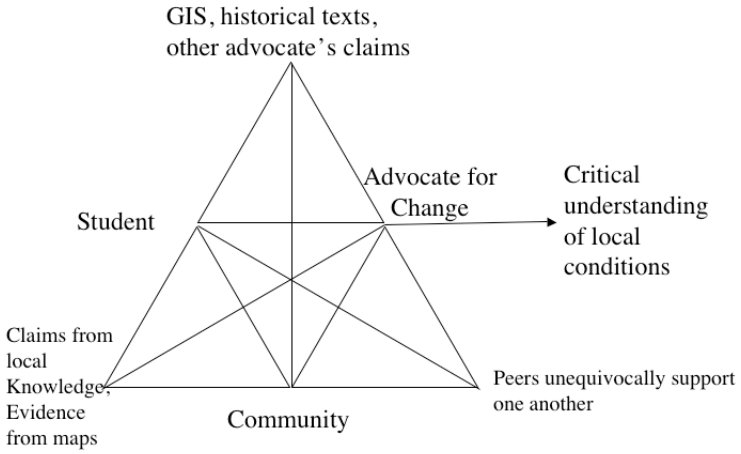

Figure 3: Actual Activity System: Advocacy-Oriented

Illustrating the Tension

One of the goals of CMP was to explicitly value students' local knowledge of their community. This eventually became a social norm for the students. However, the goal of valuing students' local knowledge was sometimes in tension with the statistical goal of engaging in discussions of counter evidence. This goal of addressing counter-evidence was dependant on the development of a sociomathematical norm (i.e., a social and discursive norms specific to mathematical contexts/activities) of taking a critical stance towards evidence. To illustrate this, Excerpt 1, presents a student's description of a GIS map based on the 9th grade graduation rates of whites and non-whites. Norma, the student, utilized her local knowledge to associate map colors with race even though the map only displayed income levels (see Figure 1).

Excerpt 1: Norma's interpretation of a GIS map

Norma	Oh the—the darker green is white--the rich people
Patrick	Okay (background laughter)
Norma	Okay and the light yellow and light green—whatever you want to call it—is that a African American (and) Hispanic
Patrick	Okay
Norma	What's the Hispanic--wait a minute
Patrick	Well yea==
Norma	==No, yea the light green
Patrick	right
Norma	Is the middle class--poor people (.) middle class I would say

Excerpt 2 is the response to Norma's description by Patrick, one of the project designers. As the response demonstrates, Patrick draws a distinction between "one set of descriptions" provided by Norma versus what the "actual data" says.

Excerpt 2: Seminar leader's response to Norma's interpretation

Patrick So Norma gave us one set of descriptions. What—what does the actual data say that the dark green is and the lighter colors. Norma was touching upon what the data are taken from but then going off into her own understandings of the neighborhood. You see what I mean. So remember when Ann started off, the darkest part of the green was the areas that had the highest percentage of white people in the census tract, and the lightest yellow, right? Were the areas that had fewest numbers of white people. The fewest percentage in those census tract. So what Norma was saying was very similar to that. She was taking some of her own knowledge and putting it into the map as well.

While Patrick does an excellent job of honoring Norma's local knowledge he also provides counter evidence while pushing for a more critical look at the data. However, as the Excerpt 3 demonstrates, when the researchers in this study used counter evidence to promote the use of statistics, the students' often challenged the statements by resorting to their personal experience and knowledge of the local community as promoted by the culturally relevant goals. In the following instance, Roberto used to live in one of the areas being discussed as a part of the project.

Excerpt 3: Student uses local knowledge to challenge counter evidence provided by researcher

Researcher Before you go to a new map can I ask you a question about this one? See, you guys were talking about whether or not there were blue dots in, in the yellow areas, red dots in the darker areas. But did you look at the, the statistics (for the blue dots)? And so if you look at the blue dots, you would have.... What do you guys think of this then? What do you(.3) There are exceptions.

Roberto I should do the Santa Monica (part) it might be (better) because I know that in Santa Monica, the rent is extremely high. And a lot of the, a lot of the traditional families that lived in, lived in Santa Monica for over 51 years had to move away because of the rent and the housing price.

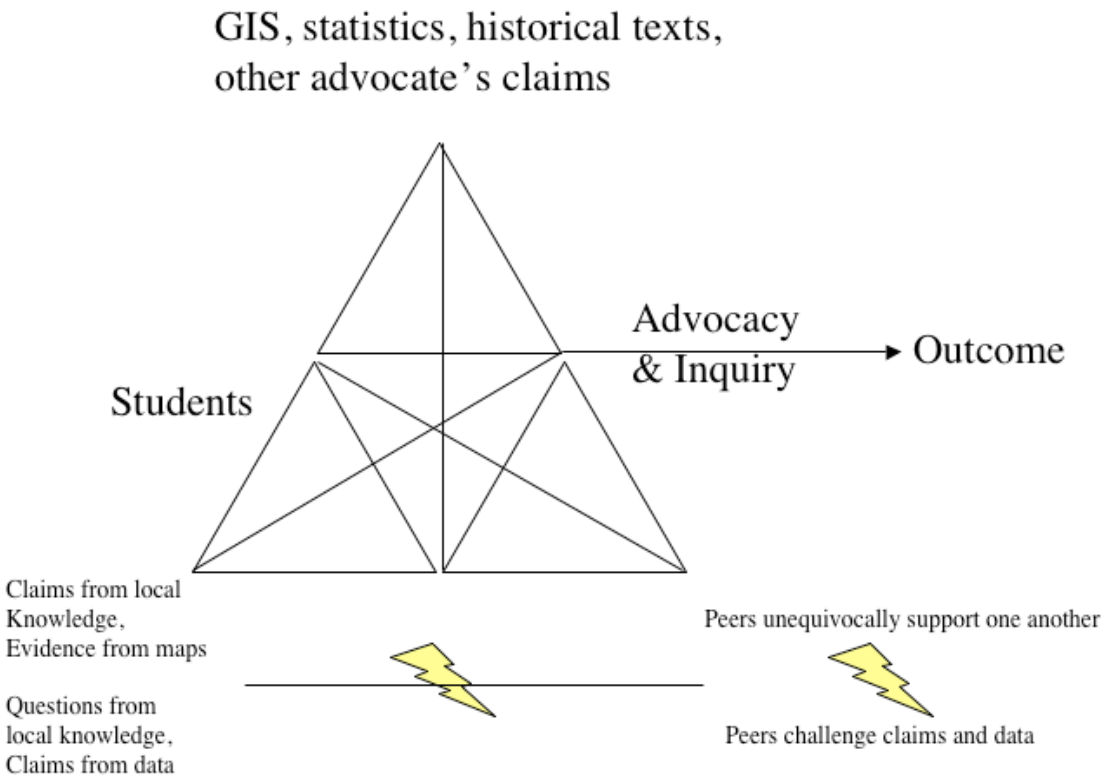

Figure 4: Highlighting the Breakdowns

Figure 4 provides and illustration of the contradictions that are evident in this series of exchanges, represented by the lighting bolt. It turns out that different objects of activity, suggested by the multiple curricular goals, provided a contradictory set of rules or norms and a conflicting division of labor. The norm of providing claims from local knowledge was in contradiction with the norm of providing evidence from the maps, while the norm of asking questions from the local knowledge appeared to contradict the norm of making claims from the data. This set of contradictions complemented those that we saw in the division of labor between the students where the culturally relevant aspect of the community appears to have encouraged the students to support each other unequivocally when speaking from their local knowledge, the statistics curriculum sought to promote critical challenges of claims and their data.

While the existence of social norms to construct arguments consistent with students' local knowledge does not necessarily preclude the development of sociomathematical norms around adequate evidence, in this project, the value placed on what students already knew often sidetracked what would have been productive, critical discussions about what constitutes adequate and convincing evidence for a claim. There is good reason to believe that if socio-mathematical norms had developed, they would have created and promoted opportunities to discuss the statistics at a deeper conceptual level (Cobb, 1999; Cobb, Stephan, McClain, and Gravemeijer, 2001).

DISCUSSION

In many ways our findings are consistent with a large body of research that has argued that classroom culture—the values, rules, roles, rights and responsibilities of the teachers and students—and the way culture shapes instructional conversations is just as important, if not more important, than any technological tool or curriculum. Despite the challenges encountered in this project, we strongly believe that the tensions described in this paper cannot be resolved by simply telling students the right way to reason about data and to support their claims—to essentially adopt only those rules and divisions of labor that were promoted in the statistics curriculum. That route privileges statistical goals over other legitimate goals of a culturally relevant pedagogy in ways that will ultimately undermine the learning of statistics for this population of students. Furthermore, this would have been accomplished by ignoring the important role that culturally relevant pedagogy played in orienting our students towards the issues with a critical and interested eye. Instead, we need to pursue the question: What kinds of activity and discourse structures are necessary to facilitate statistical learning while leveraging the benefits of a culturally relevant curriculum? Our preliminary answer to this question is to further explore the mechanisms for creating sustainable "third spaces" (Gutierrez, Rymes, and Larson, 1995). In these hybrid learning-environments the official script of the classroom is combined with the counter script of the students to create a space that can transform what is considered a legitimate resource for academic pursuits, and the relationship between students and the teacher. A better understanding of these types of hybrid spaces has the potential to help teachers and curriculum designers navigate the tensions discussed in this paper in a way that will engage a broader spectrum of youth to achieve academic success.

Fortunately, our analysis also provides some suggestions for first-steps in developing a third space between culturally relevant pedagogy and statistical argumentation. In our ongoing design work, we examined the previous curriculum with an eye towards situations where the advocacy aspect of the curriculum was successful in developing the kinds of practices that we wanted the students to participate in with statistics, but which had previously been a source of contradiction. These contexts then provide a starting point for bridging between the two sets of curricular goals. For example, the advocacy curriculum already promotes a critical stance towards the social conditions that the students in the CMP were studying. In future iterations of this project, we plan on leveraging this critical stance towards conditions to promote a more critical stance towards evidence. Statistics can then be promoted as a tool to support and implement this critical stance. In this way, it should be possible to resolve the

contradictions between the culturally relevant pedagogy and the statistical pedagogy not by privileging one over the other, but by using one as a starting point to effectively bridge into the other.

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