URBAN AND RURAL HIGH SCHOOL STUDENTS' PERSPECTIVES OF PRODUCTIVE PEER CULTURE FOR MATHEMATICS LEARNING

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ABSTRACT

The purpose of this study was to determine students' perspectives about productive peer culture (PPC) in general and for mathematics learning. The urban and rural high school students in this study have participated for at least one year in either an Algebra Project Cohort Model (APCM) for daily mathematics instruction and/or worked as mathematics literacy workers. These initiatives immersed students in mathematics thinking and learning cultures. This study used qualitative methods to interpret students' perspectives about PPC. The findings, informed by students' perspectives, determined that a productive peer culture for mathematics learning required collaboration, communication, positive dispositions, deep thinking, and peer support. One implication of this study is that education stakeholders may gain insights for changing student behaviors for learning. A second implication is that APCM and mathematics literacy work may be viable pathways for transforming high school mathematics culture for learning that prepares students for the knowledge work required for the 21st century.

Introduction

Reasoning and sense making should occur in every mathematics classroom every day. In such an environment, teachers and students ask and answer such questions as "What's going on here? and "Why do you think that?" (National Council of Teachers of Mathematics [NCTM], 2009, p. 5)

The above statement highlights a vision for learning that has been evolving for several decades for improving mathematics learning and teaching—the need for students to actively participate in mathematics classrooms and for teachers to create opportunities for students to participate (Kilpatrick, Swafford, Findell, National Research Council [NRC], & Mathematics Learning Study Committee, 2001; NCTM, 1991; 2000). These ideas suggest more effective mathematics teaching and greater learning by way of sociocultural shifts in classrooms. The call for mathematics classroom changes has been consistent since the introduction of the mathematical process standards via NCTM's Principles and Standards for School Mathematics (PSSM), subsequent publications (Martin & Herrera, 2007; NCTM, 2000; Strutchens & Quander, 2011), and the development of the Common Core State Standards for Mathematics mathematical practices (Common Core State Standards Initiative [CCSSI], 2010).

Importantly, mathematical practices and processes should infuse sociocultural elements into mathematics teaching (Goos, 2004; Russell, 2012). Research has documented how mathematics classrooms are influenced by sociocultural contexts (Brown & Hirst, 2007). Further, teaching and learning designed for developing mathematical understanding is a sociocultural endeavor (Choppin, 2004; Goos, 2004; Hiebert et al., 1997). It follows that the sociocultural nature of mathematics classrooms are influenced by all who inhabit them—

teachers, students, and community members. Each of these classroom constituents' perspectives can inform sociocultural changes needed for developing mathematical understanding.

This study reports findings that are part of a five-year, NSF-funded investigation to understand how the Algebra Project Cohort Model (APCM) affected mathematics classroom environments and influenced mathematics literacy for underserved students (Moses, Dubinsky, Henderson, & West, 2013). The current study shares findings developed through year two of the project and included students from two sites. This study sought to understand students' own perspectives and experiences about productive peer cultures (PPC) for mathematics learning. The guiding research questions were:

1. What perspectives do high school students have about PPC?
2. What perspectives do they have about the influences of PPC on their mathematics learning?

Findings of this study provide insight into how a group of urban and rural students perceive themselves as mathematics learners. Their perspectives can inform classroom teachers, administrators, and policy makers who endeavor to improve mathematics learning and classroom environments.

Literature Review

This section conceptually frames this study and situates it within the literature on effective mathematics learning in classrooms through two themes—first, community and culture, and, second, productive peer cultures.

Community and Culture

Many urban and rural high school mathematics classrooms have disproportionate numbers of students who continue to be underserved by schools in the U.S. (Anyon, 2006; Hardy, 2005). An underlying assumption is that these students are well-served by remedial interventions (e.g.., repetitious skill-based practice), but there are better approaches for closing academic gaps (Fisher, Frey, & Lapp, 2011). However, research suggests culture and community can positively influence mathematics learning (Ares, 2006; Walker, 2006), student participation (Sullivan, Tobias, & McDonough, 2006), and opportunities for students to learn (Hand, 2010).

Generally speaking, learning is enhanced when community and cultures are positive and supportive, and hindered when they are not. For example, Fisher, Frey, and Lapp (2011) targeted school community and learning culture for increasing attendance and student engagement that led to community and culture that improved achievement. Similarly, Hardré, Crowson, Debacker, and White (2007) showed how factors such as student perceptions of classroom climate and teacher effort were positively related to student perceptions of learning, goal setting, and school and classroom engagement. Conversely, when community is unsupportive and cultures unproductive, learning is negatively influenced. For example, other studies found that urban and rural students choose not to participate in unsupportive or unproductive learning settings (Hendrickson, 2012; Sullivan et al., 2006). Hardré et al. (2007)

described this behavior as performance avoidance, which was negatively related to school engagement and effort. These findings suggests that urban and rural students are similar, and they benefit from positive learning community and cultures that lead to setting learning goals, expending effort, and choosing to participate.

The Algebra Project, Inc. curricular approach infuses community and culture through the application of experiential learning theory, described by Moses and Cobb (2001)) as ". . . cyclical experiences in which people try something, then think about what they did, and then make improvements, then practice their improvements" (p.198). This approach allows access and opportunity for participation and mathematical understanding. The Algebra Project Cohort Model (APCM) supports and encourages pedagogies that engage students' lived experiences and creativity as a part of their mathematics learning. The assumptions built into the APCM are supported by research that finds that students from all geographic regions preferred learning that affords creativity and fun (Johnson, 2006). Approaching mathematics experientially opens access and is an innovation for mathematics learning environments while affording different cultures than remediation-focused classrooms (Moses & Cobb, 2001).

Productive Peer Cultures

Research supports that PPCs faciliate student enagement, thinking, creativity and positive dispositions toward learning. For instance, Moses and Cobb (2001) described mathematics cultures for urban and rural students that require creativity, active engagement, and self-reliance. The NRC (Kilpatrick et al., 2001), on the other hand, described students' productive mathematical dispositions as positive beliefs about mathematics, persistent engagement, and a focus on personal fulfillment. Implementing sociocultural changes inspired by NRC and other standards (CCSSI, 2010; NCTM, 2000) requires transforming mathematics classroom cultures, from traditional—where expert teachers show and tell passive students (Freire, 1970; Tyner-Mullings, 2012)—to productive cultures—with collaborative communities for sense making (Choppin, 2004; Moses & Cobb, 2001; Sfard, 2001). Research insinuating the importance of PPC includes the foundational TIMMS study that identified classroom social culture as a key dimension of mathematics classrooms for developing mathematical understanding (Hiebert et al., 1997) as well other other more recent studies (Grant, 2009; Sfard, 2001, 2007; Sfard & Kieran, 2001).

Methods

Qualitative methods—iterative cycles of constant comparisons—were used to interpret students' verbal and written responses to understand their perspectives, which makes the methods appropriate (Denzin, 1997).

Participants and Site

The two-week residential APCM Summer Institute included students from two different APCM sites from the Midwestern U.S., one urban and the other rural. The students had been involved with APCM for one to three years through daily mathematics instruction and/or as mathematics literacy workers for the Young People's Project: Math Literacy and Social Change (n.d.). These affiliations afforded a purposeful sample of participants given their experiences collaborating and engaging in PPC.

Twenty-six students (twelve males and fourteen females) attended the summer institute and participated in the study, fifteen of whom were urban and eleven rural. Both school contexts were characterized by high poverty and limited parent support for learning (Bishop, 1989). The two groups differed on race and gender ratios—the urban students self-identified as Black or bi-racial, with eight males and seven females; the rural students self-identified as White or multi-racial (non-Black), with four males and seven females.

Data Collection

The student data included: a) audio recordings (approximately 220 minutes) - group collaborations and reflections; b) written artifacts - notes, summaries, and concept maps; c) video recordings (approximately 40 minutes); and d) audio recorded (45 minutes) mathematics learning sessions from the second week of the summer institute. The majority of the data was collected during the two working sessions: a) an introductory session that started the institute; and b) a reflective session that ended it.

Introductory session (90-minutes). First students wrote PPC characteristics. Then to ensure an early morning engaging experience, diverse collaborations were shown using clips from Monsters, Inc. (Disney Enterprises Inc./Pixar Animation Studios, 2001). Most students knew the story, allowing random clips to be shown without compromising understanding. The researcher's and students' perspectives about clips are compared in Table 1.

After each clip, groups identified peers in the scene, decided if collaborations were PPC, explained their positions, and reached group consensus. Then the class was polled, and when groups differed, positions were persuasively argued providing rationales until class consensus or an agreement to disagree was reached. Before leaving, students were encouraged to initiate and look for PPC during the institute as they learned mathematics. Finally, students were told of the PPC reflective session on the last day.

Reflective session (60-minutes). Students were asked to share instances of PPC related to mathematics learning either verbally or in writing. Few opted to write, but several documented accounts via recording. Two audio recorders were passed among students while they shared recollections within groups. After about 30 minutes, groups created concept maps that depicted their thinking about PPC for mathematics learning.

Data Analysis

Inductive analysis was utilized to examine the student data. This method of analysis involved identifying interpretive themes from reviewing the data (Creswell, 2009; Patton, 1990). The inductive analysis process began with a thorough examination of the data—reading and listening multiple times while searching for patterns. Themes were refined by finding redundancy in multiple sources or participants.

Qualitative interpretation methods were used for interpreting the students' perspectives (Wolcott, 2001). By carefully examining student artifacts (e.g., PPC characteristics and concept maps), thematic patterns emerged for coding. This analysis revealed a PPC definition, then the two working sessions, PPC accounts, and the classroom recordings were coded searching for supporting (or contesting) evidence.

Results and Findings

Results

The students' perspectives differed from those of the researcher and this became evident after the introductory workshop (see Table 1). For example, in clip two ("Monsters in the Closet"), the researcher's perspective was "no PPC"; students expanded the peer group and described the interaction as "negative PPC." The students focused on the interaction outcome versus the cultural context for interaction. A student noted, "PPC can be negative or positive, but the outcome is what needs to be productive" (Introductory Session, July 2011).

The students' and researcher's perspectives aligned as more clips were considered (see Table 1). Several student PPC perspectives that emerged during the introductory session persisted and re-emerged for their mathematics learning (see *italicized* text, Table 1). For example, a persistent theme started as *shared goal* and became "common goal." An indirect example that persisted was *intent* and became "positive personal disposition."

Table 1
Examples and Non-Examples of Productive Peer Culture for Scenes Used During the Introductory Session 1

	Researcher's Perspectives			Students' Perspectives	
Scene # - Title	Peer Group	PPC (Y|N)	Characteristics of PPC	PPC (Y|N)	Characteristics of PPC
2 - Monsters in the Closet	Scare recruits	N	No peer communication or teamwork	Y|N	"Negative PPC" with *productive outcome* (i.e., feedback about scaring); peer group included tester and Mr. Waternoose
4 - Morning Workout	Sam & Sulley	Y	Teamwork, shared goal	Y	"Positive PPC" with *productive outcome* (i.e., good preparation for scaring); *good relationship* and interaction; *shared goal* – scaring
8 - Scare Floor	Multiple Scaring teams	Y|N	Collaborative, argumentative, supportive, competitive	Y|N	"Negative PPC" persists [some students are beginning to question this as not PPC when interactions are negative, such as] "Randal's *intent* is selfish"
12 - Harryhausen's	Restaurant monsters	N	Uncooperative, every monster for itself, chaotic	N	No time to fix problem (i.e., get rid of Boo); *no focus*, chaos
14 - Bedtime	Sam & Sulley	Y	Sense making, planning, teamwork, common goal		Clip not used due to time

The most coded themes are presented in Table 2 and were interpreted as representing students' perspectives about PPC. The percentage of data sources coded (column 2) shows the highest frequency coded themes with redundancy by sources (types and groups), which strengthened the validity of findings via source triangulation (Lather, 1993).

Two themes were most represented within the student data—collaboration for learning (93%) and mathematics communication (70%) (see Table 2). The remaining high represented themes, each found in greater than 50% of data sources coded were positive personal dispositions (63%), peer support (56%), and cognitive demand (56%). Alternatively, when identifying the most coded themes the order varies but the themes remain the same, further strengthening the findings by triangulation (Lather, 1993).

Table 2
Data Analysis Summary of Coded Themes with Examples from the Data

Theme (Code)	Sources Coded	Times Coded	Data Source Group #	Examples of Student Voice from the Data
Collaboration for Learning	93%	60	Reflective session	They [peers] broke it down to the point where I could really grasp it
			Introductory session	Working together with friends/co-workers on something you believe in
Mathematics Communication	70%	36	Concept Map 3 Concept Map 1	Common language; verbal; and non-verbal Talking to one another about roles, activities, and/or the work
Positive Personal Dispositions	63%	40	Characteristics 5	Young people can develop self-worth around a negative youth subculture
			Concept Map 2	Sacrifice; loyalty; positive attitude
Peer Support	56%	39	Characteristics 4 Reflective WS	Constructive criticism D came over and worked with T to really motivate them
Cognitive Demand	56%	39	Concept Map 6 Characteristics 7	Taking ideas and turning them into actions When there is a challenge

Findings: What Perspectives to High School Students Have about PPC?

Very early during the introductory session, students articulated the five themes for PPC that persisted throughout the institute (see Table 2). For example, during the Introductory Session about clip two, students from group 1 argued "not PPC":

> His peers are terrible. When they asked the peers, what he did wrong? They didn't know. They supposed to know.
>
> —Student 1, Introductory Session, July 2011

> The lady asked for their feedback, they didn't give it, 'cause they were dead [nonresponsive]. Once she answered, they [monster peers] figured it out. That's not productive. They're not working together and they basically gave up until she said it.

—Student 2, Introductory Session, July 2011

In this rationale, three of the persistent PPC themes emerged—positive dispositions, communication, and collaboration. The monster peers were described as "terrible" and "dead," as having negative dispositions, being not communicative, and "not working together." The students mentioned the monsters were not trying or not cognitively engaged when they said, "they supposed to know" and "they basically gave up until she said it." The monster waited for the answer. The students' position was that the monsters were not engaged in thinking about scaring and did not offer ideas.

The final characteristic, peer support, was well articulated in group 2's explanation supporting PPC for clip four ("Morning Workout"): "He was pushing him to work, to be better than what he was" (Student, Introductory Session, July 2011). Students believed peer support helps one be more than s/he might individually. Students relying on one another was evidenced in their comments and observed during the classroom learning at the institute.

Findings: What Perspectives do High School Students Have About Influences of PPC on Their Mathematics Learning?

The students who attended the institute chose to engage in mathematics for two weeks after school ended. An assumption of this study was that students would learn mathematics during the institute and the experiences could be easily recounted after the two weeks. One group of students' definition for PPC during the reflective session was as follows:

> We're the ones who make up peer productive culture without us then there's nothing. We're the ones who have to give the support to each other. We as peers have to show and give communication to each other. We as young adults must take on leadership to overcome different obstacles in life. Us as leaders, have knowledge to make a change of production that we do. It's all on us.
>
> —Reflective Session, July 2011

After this articulation, other students made utterances about their concurrence, such as "There is nothing more to say," and "They said it all."

The data analyses revealed a second tier of themes—commitment, agency, leadership, and engagement—as measured by percentage of sources coded and times coded. The previous quote includes these four and the aforementioned five PPC themes.

These themes are central in most students' PPC accounts. For example, one student arrived after the introductory session and was briefed by another with the following description:

> Productive peer culture is pretty much like you and your peers getting together and tryin' to make something good of the situation. Like if y'all tryin' to do a math problem, you and your whole group are trying to figure it out. Not just a few people, but everybody is trying to do the one thing to figure it out.
>
> —Reflective Session, July 2011

The student describes PPC as "getting together and tryin'" (i.e., collaborating, agency) and "everybody is trying . . . figure it out" (i.e., commitment, engagement).

A second example of PPC from a student's account offers a global perspective that characterizes mathematics learning during the institute:

> The hard work showed off. Everybody got stuff done, everybody who was slackin' picked up the slack and that's all it is, they worked hard in different groups and some of the people they didn't even like but they got over those foes and worked hard and worked together.
>
> —Reflective Session, July 2011

This brief account mentions cognitive demands as "hard work" multiple times. Agentic behaviors are included: "got stuff done" and working with "people they didn't even like." Positive dispositions included "picked up the slack" and "got over those foes." We offer one final example of a student's PPC account:

> Another way was when T's theorem was being done. Uh, J went up to the front and helped them out without actually taking over their theorem. He like was squatted down at the board and helped them work through it, and helped them push the theorem forward. And when people talk about T's theorem they talk about T and A, and they forget that J was even up there.
>
> —Reflective Session, July 2011

In this account a very relevant but implied PPC theme is J's leadership, as seen in the comment "helped them without actually taking over." This event occurred during the observed classroom session. The presenting students were stuck; J was not a member of the group presenting, but he went to the board and helped. His action was recognized by his peers; they discussed it after class.

Informed by the data, the analyses, and literature, the researcher posits a PPC definition:

> Students work hard in collaboration with peers in pursuit of a common goal. The students are committed to ensuring mathematical understanding for themselves and others. They exhibit sufficient confidence to respectfully communicate their mathematical perspectives to the world and sometimes provide mathematical leadership.

In summary, students' perspectives about PPC for mathematics learning include: a) collaboration for learning requires respect and deep thinking focused on common goals; b) learning mathematics is a commitment; c) gaining understanding supports self and peers, including those not considered friends; and d) mathematical agency and sometimes leadership manifests in positive outcomes that should be communicated. These findings suggest students' awareness of what is needed to develop PPC for mathematics learning.

Discussion

This study about students' perspectives about PPC for mathematics learning offers insights from students for students, teachers, administrators, and policy makers interested in transforming mathematics classroom cultures for improved learning. Effecting change within high schools located in urban or rural communities has been especially challenging and requires comprehensive support structures (Fleischman & Heppen, 2009). The literature offers much with respect to descriptions of effective mathematics learning environments, what to teach, how, and when (CCSSI, 2010; Hiebert et al., 1997; NCTM, 1991; 2000). However, none of these include students' perspectives.

One implication from this study is that PPC is not likely to emerge in mathematics classrooms taught using only traditional approaches. PPC requires collaborative thinking and supporting peers for mathematics learning. Most urban high schools rely on and advocate for traditional teaching methods and do not utilize mathematical practices or processes for several seemingly "good" reasons (Haberman, 1991, 2010). Haberman describes traditional teaching environments as spaces for compliance, non-supportive climates, and anti-peer communication; students lead through compliant or distractive learning behaviors. These student behaviors are the antithesis of those described in this report for PPC.

A second implication of this study is the introduction of students to the mathematics education discourse. These students, typically labeled "at risk," were aware of what they needed and informed our vision for transforming mathematics classroom cultures. More widely accepted approaches for reform include curricular development, remediation, and accountability systems (Fleischman & Heppen, 2009). If APCM initiatives can be shown to consistently influence PPC among underserved students, a new approach for reform is added to that list.

The final implication of this study is the potential benefit to students. Many approaches to reform require teachers, administrators, and other adults to effect change, but this study's findings suggests galvanizing students to change their behaviors and ways of interacting with peers for learning. When students change their culture, that change is likely to be long-lived because culture follows the person (Ares, 2006; Nasir, 2002; Walker, 2006). Adding students' perspectives as yet another spoke in the wheel of mathematics education reform strengthens our progress to improve mathematics learning and teaching.

More research is needed to further theorize the specifics about PPC and ways to manifest it in classrooms. We need to understand how the APCM initiatives contribute to the emergence of PPC, while also determining alternative initiatives for developing PPC. Finally, benefits may emerge from questioning students about other ideas they might offer for improving their mathematics learning, teaching, and their environments.

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