Education and Urban Society
2019, Vol. 51(8) 1029–1050

Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/0013124518785017
journals.sagepub.com/home/eus
SAGE

"How You Like Me Now?": Exploring Teacher Perceptions of Urban Middle Schoolers' Mathematical Abilities and Identities

Tori K. Flint[1], Peter Sheppard[1], and Nii A. Tackie[1]

Abstract

HEAT, an instructional program emphasizing a nontraditional hands-on approach to algebraic instruction for urban, predominantly African American middle schoolers, provides a space to explore teachers' beliefs about urban students' mathematical abilities and motivation and addresses how teacher perceptions can intersect with instruction, learning, and the construction of students' mathematical identities. Using a multiple case study design, we analyzed six urban middle school mathematics teachers' written reflections and interview responses. Findings suggest that teachers' instructional behaviors, along with their perceptions and expectations of urban, African American middle schoolers' mathematical abilities and motivation, interact with students' beliefs and work habits in ways that can promote and support students' positive mathematical identity construction. Thus, HEAT personified thriving learning subcultures and supportive mathematical communities of practice that are far too atypical in urban middle schools.

[1]University of Louisiana at Lafayette, USA

Corresponding Author:
Tori K. Flint, University of Louisiana at Lafayette, P.O. Box 42051, Lafayette, LA 70504, USA.
Email: tflint@louisiana.edu

Keywords
urban education, teachers, students, identity, mathematics

A plethora of research indicates that urban youth are more likely to struggle with algebra on measures of academic success, thus decreasing the likelihood that they will have the kind of future career success typically associated with algebraic proficiency (Jackson & Wilson, 2012; Ladson-Billings, 1997, 2000; Martin, 2000). According to the 2015 National Assessment of Educational Progress (National Assessment of Education Progress [NAEP], 2015) that tested fourth and eighth graders in math and reading, test scores demonstrated that only 40% of fourth-grade and 33% of eighth-grade students performed at or above the *Proficient* level in mathematics. Within these national percentiles, only 19% of African American fourth-grade students and 13% of African American eighth-grade students ranked at the *Proficient* level. In Louisiana, these scores are noticeably lower with only 30% of fourth graders and 18% of eighth graders meeting the level of proficiency in mathematics. This is particularly alarming in an era when algebraic proficiency is described as a new civil right, an avenue to economic liberation (Moses & Cobb, 2001), and a demonstrable gateway to later achievement while being highly correlated with success in college—a social escalator (US Department of Education: National Advisory Panel, 2008). Conversely, ineptitude in learning mathematics, specifically algebra, can limit individual possibilities and opportunities for social mobility and can hamper state and national growth (National Research Council, 2001), essentially barricading gateways to achievement and future success.

Major contributors to urban middle school students' difficulties with algebra include pedagogical approaches that are often almost exclusively abstract (Jackson & Wilson, 2012). Similarly, difficulties among middle school students with mathematical concepts are often linked to negative mathematical identities (Bonner, 2014). In response to disparate scores such as those noted by NAEP, the Hands-on Exposure to Algebraic Topics (HEAT) Project was developed to provide a pedagogical approach that focuses on conceptual understanding to support urban students' learning of algebraic content.

Students participating in the HEAT Project learned how to solve linear equations with one unknown in cooperative, after-school environments grounded in the use of *Hands-On Equations* materials (Borenson & Barber, 2008). At the conclusion of the program, students participated in a team-based algebra competition. The project included six urban Louisiana middle schools and had an overarching goal of promoting academic success and positive mathematics identities within these schools' predominantly low-income (Title-I) and African

American student populations. Specific aims of the project included cognitive outcomes for student participants centered on mastery of foundational algebraic concepts, pedagogical outcomes for teachers through alternative teaching methods, and affective outcomes for teachers as measured by teacher perceptions.

This study highlights aspects of the HEAT Project that support students' mathematics learning. It further focuses on the initial teacher perceptions of the students involved in the HEAT Project and the analogous mathematical identities constructed by the students and teachers. It centers on the ways teachers were able to change their views and support students as they became successful in learning algebraic concepts. Our interest in discussing teacher perceptions of urban, African American students' mathematical abilities and motivation and the students' corresponding mathematical identities within the context of the HEAT Project arose after initially examining interviews in which middle school math teachers repeatedly described the various students who struggled to learn algebraic concepts in similar, deficit-focused ways.

This study is driven by these factors and aims to answer these broad research questions:

> **Research Question 1:** How does HEAT support students' mathematics learning?
> **Research Question 2:** How do teacher expectations and perceptions of urban, African American students affect students' mathematics learning?

For more urban, African American students to overcome negative stereotypes about their mathematical abilities and motivation, to begin to construct positive mathematical identities that they will carry with them throughout their academic careers and beyond, and to counter the notion that urban students are equated with underachievement in mathematics, it is important to identify components within projects such as HEAT that foster academic achievement and growth. It is also essential to focus on stories of students' mathematical successes and positive mathematical identity construction and on the ways that teacher perceptions of urban, African American students affect student motivation and learning.

The HEAT Project: An Integrated Theoretical Framework and Literature Review

Several theoretical frameworks intersect to undergird the aims of the HEAT Project in fostering algebraic confidence and ability and in supporting the creation of positive math mindsets among urban middle school students.

Interwoven with recent scholarly work that highlights the importance of teacher perceptions and students' positive mathematical identities in achieving academic success, the constructivist, social constructivist, and situated and social learning frameworks coalesce and scaffold the HEAT Project design, goals, and the analysis of the findings.

Gloria Ladson-Billings (1997, 2000) notes that urban and African American students have consistently and systematically been told that they are inferior and that they are incapable of high academic achievement and success. Oftentimes, teachers hold negative assumptions about the skills, abilities, competencies, and motivation of students who do not come from middle-class or upper-class backgrounds and/or whose race or culture differ from their own (Martin, 2000). Correspondingly, the performance of many urban and African American students in school replicates these low academic expectations (Ladson-Billings, 2000).

Teachers often blame urban and African American students, along with their families and communities, for their mathematical (and general academic) underperformance (Bol & Berry, 2005; Jackson & Wilson, 2012; Linn, Bacon, Totten, Bridges, & Jennings, 2010). These teachers often hold a *deficit perspective* in which they tie social class and family structure to the students' perceived lack of mathematical readiness and ability. They also often link students' low socioeconomic status with depressed mathematical experiences and a lack of parental support in teaching children foundational math concepts (Martin, 2000). It is important for teachers to reframe these views of students to move beyond negative stereotypes and to understand and support students' developing mathematical identities (Martin, 2000). It is therefore necessary, in urban schools with predominantly low-income, African American student populations, to include learning goals that support the development of *positive* and robust mathematical identities to promote academic achievement and success in these contexts (Jackson & Wilson, 2012; Martin, 2000).

Research suggests that teachers who support urban, low-income, and African American students' in positive ways *believe* that they are capable of academic achievement and success, create classroom supports and build relationships to scaffold student learning, and help students develop confidence (Ladson-Billings, 1995). These teachers view students from *additive perspectives* or from *empowerment orientations*, wherein students' experiences, cultures, and funds of knowledge are valued and built upon to facilitate learning and instruction in the classroom context (González, Moll, & Amanti, 2006; Gutstein, Lipman, Hernandez, & de los Reyes, 1997).

Educators and researchers generally agree that instruction should be aimed toward supporting students' development of positive and productive academic mindsets to foster mathematical development and confidence (Boaler & Greeno, 2000; Cobb, Gresalfi, & Hodge, 2009; Jackson & Wilson, 2012; Martin, 2000). Educators and researchers also generally posit that mathematics instruction should support students' conceptual understandings and procedural fluency (Jackson & Wilson, 2012). Guided by the combination of these principles, the HEAT Project was developed to accelerate algebraic proficiency and to support the development of positive mathematics identities among urban, low-income, predominantly African American middle school students prior to their formal introduction to algebra. This collaborative, nontraditional, hands-on approach to conceptual mathematics learning provides teachers with a pedagogy that allows students to actively model and solve algebraic equations utilizing concrete, hands-on manipulatives, solve algebra problems by drawing pictorial representations, and work with teachers and peers in an environment that is relaxed, recreational, supportive, interactive, and cooperative.

Due to the active, social nature of the knowledge construction noted within the HEAT Project, it can be viewed, overall, through a constructivist lens. This overarching view is further informed by a combination of components drawn from social constructivism and situated and social learning theories. Each of these theories individually and mutually supports the focus of the HEAT Project in fostering the development of urban students' mathematical learning and positive identity construction.

Constructivism

Constructivism is a theory, rooted in psychology, about how people learn. It suggests that people construct their own understandings and knowledge of the world by experiencing things and then reflecting upon those experiences. Constructivism further posits that learning is an active and contextualized process of knowledge construction. Knowledge is constructed based upon personal experiences and hypotheses of the learning environment. Learners have different interpretations and knowledge construction processes that are informed by past experiences, as well as social and cultural factors (Bruner, 1961; Vygotsky, 1978).

In the mathematics classroom context, a constructivist view of learning suggests a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques (hands-on learning, real-world problem solving, etc.) to construct knowledge and then to reflect upon and discuss their hypotheses and their understandings. Teachers act as facilitators in this context and make sure they understand the students' preexisting conceptions and their needs and then guide the learning activities accordingly, to address and then build upon them.

Social constructivism. Social constructivism, strongly influenced by Vygotsky's (1978) and Bruner's (1961) works, suggests that knowledge is first constructed in a social context and is then appropriated by individuals (Bruning, Schraw, & Ronning, 1999). As an extension of constructivism, social constructivism states that learning is an active, social process in which students construct new ideas or concepts based on their current knowledge (Bruner, 1961). According to social constructivists, the process of sharing individual perspectives and understandings can result in learners constructing knowledge together that might not have been possible on their own (Greeno, Collins, & Resnick, 1996). Vygotsky further elaborated upon the social aspect of learning when he defined the *zone of proximal development*, wherein students are able to solve problems beyond their actual developmental level (but within their level of potential development) under adult guidance or in collaboration with more capable peers (Vygotsky, 1978). Social constructivism not only acknowledges the uniqueness and complexity of each individual learner but also encourages, utilizes, and rewards it as an integral part of the learning process in social contexts (Wertsch, 1988). Learners discover principles, concepts, and facts for themselves through cooperative, active, hands-on experiences and hypothesis construction, encouraging guesswork, collaboration, and intuitive thinking (Brown, Collins, & Duguid, 1989). Many constructivist scholars agree and emphasize that individuals make meanings through their interactions with others and with their environment(s) (Bruner, 1961; Greeno et al., 1996; Vygotsky, 1978). Knowledge is thus socially and culturally constructed (Ernest, 1994; Prawat & Floden, 1994), and learning is an inherently social process (McMahon, 1997).

The HEAT Project is constructivist in nature in that it incorporates the use of hands-on materials (manipulatives/drawings), experiential learning (learning by doing), and concept-based instruction that allows for learning as an active process. The team competition/game-like nature of instruction, including the use of hands-on, game-inspired materials such as chess pawns and the incorporation of a final match/competition, provides information and instruction framed in a relaxed, yet motivating context. HEAT utilizes cooperative and collaborative learning strategies to increase student motivation and confidence, positions teachers as facilitators to enhance student knowledge construction, and motivates students to participate by creating a supportive social context in which students can share and build upon their own knowledge and experience(s) and scaffold each other's learning in a fun and cooperative environment. Students are able to work within their zones of proximal development (Vygotsky, 1978), with support from their peers, to further their mathematical understandings. Students are able to actively engage in learning by using the manipulatives and working cooperatively to discuss their algebraic hypotheses, processes, and outcomes. This constructivist/social constructivist lens allows us to view various aspects of the HEAT Project and how these motivate student learning and participation, build student confidence, and promote student learning and success in math (algebra).

Situated and Social Learning Theories

The constructivist/social constructivist lens from which this study is viewed highlights the social nature of learning. Expounding upon this concept, this study is further framed by situated learning (Brown et al., 1989; Greeno, 1989), a theory that suggests inquiries into learning must seriously consider aspects of social interaction and activity. This framework indicates that learning, as it generally occurs, is a function of the activity, context, and culture in which it is situated (Lave, 1991). A unifying concept emerging from situated learning research is that of *communities of practice* (Wenger, 1998). This concept is based upon the notion that learning is constituted through the cooperative sharing of purposeful and patterned activity and that through these interactions, cohesive learning communities emerge (Lave & Wenger, 1991).

Social interaction, and thus social learning theory, is a critical component of situated learning, in which learners become integral players in these *communities of practice*. Social learning theory combines cognitive learning theory, which submits that learning is highly influenced by psychological factors, and behavioral learning theory, which posits that learning is based upon responses to the learning environment. Bandura (1977) integrated these two theories and created a framework consisting of four requirements for learning: observation (environmental), retention (cognitive), reproduction (cognitive), and motivation (both).

Furthering Bandura's social learning theory, Vygotsky (1962, 1978) submits that we learn directly through our interactions and our communications with others. His work suggests that learning takes place through the interactions students have with their peers, teachers, and other *experts*. As novice learners move from the periphery of the community of practice to its center, they become more active and engaged and, as they learn, slowly assume the role of *expert* within the community through a process called *legitimate peripheral participation* (Lave & Wenger, 1991). This process allows students to build confidence and simultaneously increases their motivation to participate in learning experiences as they construct and share their knowledge as valued experts within the group.

Learning cannot be separated from its social context (Vygotsky, 1962, 1978). Knowledge construction occurs within social settings that involve "student-student and expert-student collaboration on real world problems or tasks that build on each person's language, skills, and experience shaped by each individual's culture" (Vygotsky, 1978, p. 102). Learning is advanced through collaborative social interaction and through the social construction of knowledge (Bandura, 1977; Lave & Wenger, 1991; Vygotsky, 1962, 1978). Consequently, instructional strategies that promote the distribution of expert (student and teacher) knowledge and wherein students work collaboratively help to create effective and supportive communities of learners.

These concepts often contrast with most classroom learning activities that generally involve abstract and out-of-context instruction focused on individual knowledge construction. Many schools have traditionally held a transmissionist or instructionist model in which a teacher "transmits" information to students (Lave & Wenger, 1991). In contrast, situated and social learning theories promote learning environments in which students play active roles in their learning. Teacher and student roles shift as teachers become collaborators and facilitators and students become experts with valuable knowledge and experiences. Learning, in this context, becomes a reciprocal experience for the students and teacher.

In the HEAT Project, situated learning theories align and combine with social learning theories. Learning in this program is intentionally conceptual, hands-on, and cooperative. Students work in collaborative teams, learning from and sharing their knowledge with each other, as teachers become facilitators, guiding students' learning. Students' knowledge is valued as important and sharing *expert* knowledge within the group becomes essential to the learning context provided by the HEAT framework.

Method

Context of the Study

HEAT is one of several subgrants of the federally funded Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) project led by a local school district. The HEAT Project seeks to help urban students develop conceptual understandings of algebraic topics through the use of hands-on manipulatives. The project also provides professional development to middle school teachers who, in turn, support students' algebraic learning through the use of concrete and pictorial models in after-school, team sessions.

Teacher professional development focused on the intersection of teacher content knowledge and pedagogical knowledge. Rich discussions regarding pedagogical errors and student misconceptions supplemented the professional development sessions that focused on an interchangeable five-step process designed to equip teachers with the knowledge necessary to implement the project:

Abstract: $2x+7=x+10$
Concrete: Model $2x+7=x+10$ with concrete items using principles of equality
Pictorial: Draw a visual of $2x+7=x+10$ using principles of equality
Translate: $2x+7=x+10$ into a traditional "word" problem (i.e., If an integer is doubled and increased by seven, the result will be the same as if the integer were increased by ten. What is the integer?)
Cultural/Real Data Connection: Translate $2x+7=x+10$ into a contextual problem involving real data and/or a cultural connection (i.e., Tiger Woods' first and second round score of his last tournament were the same. If his first round score were doubled and increased by seven, it would be the same as his second round score increased by ten. What was Tiger Woods' second round score?)

Accordingly, the professional development associated with the HEAT Project is inextricably linked to the *Hands-On Equations* (HOE) approach (Borenson & Barber, 2008) in which manipulatives are used: a scale/balance representation, blue and white pawns (which represent positive and negative unknowns), and green and red numbered cubes (which represent positive and negative quantities). In this approach, pawns and numbered cubes are set up on either side of the balance. To solve the equation, "legal moves" (Borenson & Barber, 2008) must be performed to add or remove pawns and numbered cubes from both sides, until a solution is reached. Adding or removing the same type of pawn or numbered cube from both sides of the balance is considered "legal" because this represents the mathematical principle of equality by "doing the same thing" to both sides of the equation.

Teachers were also instructed on the use of pictorial representations for the physical models (the balance, pawns, and numbered cubes) to help students set up and solve linear equations. The following pictorials (Figure 1) were used to represent the physical objects: a small triangle for an unknown quantity, a rectangle with a number written in it for a positive quantity, and a circle with a number written in it for a negative quantity.

In using pictures to set up a representation for a given linear equation, a horizontal line is drawn to serve as the top of a balance. A vertical line is drawn to divide the horizontal line into two parts, the left-hand side and the right-hand side of the balance. This vertical line serves as the midpoint of the balance and is used to represent the "equal" sign within the equation. A representation of the algebraic equation $2x+7=x+10$ would be represented as seen in Figure 2.

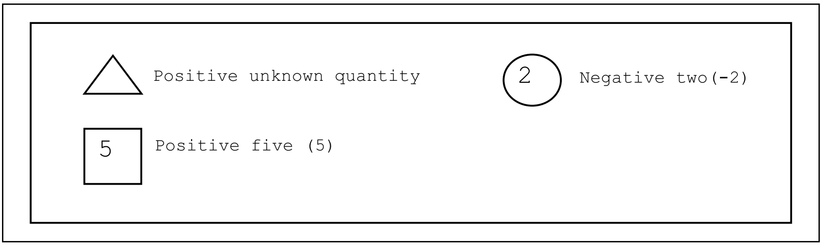

Figure 1. Symbols used in the pictorial representations.

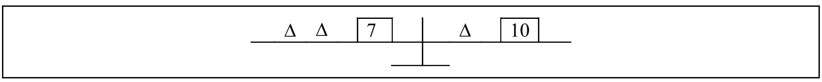

Figure 2. Pictorial representation of $2x + 7 = x + 10$.

Following the teacher trainings, middle school students were assessed on individual and then on a team basis as they participated in the HEAT practices after school at each school site and in the final, team-based competition. The HEAT competition consisted of two parts: the pictorial competition and the hands-on competition. The pictorial portion of the competition asked students to solve linear equations using *only* pictorial representations. Students were given an hour to solve 14 linear equations using only pictorial representations at their school site. This part of the competition preceded the final, team-based, hands-on competition. In the final, hands-on portion of the competition, teams of four or five students from each school competed against each other and against teams from other participating middle schools at an event held on a university campus. In this part of the competition, *only* the hands-on manipulatives were used to solve timed, linear equations. At the conclusion of the team-based, hands-on competition, students/teams were awarded several prizes.

Participants

Teacher participants were pulled from a set of 12 teachers who participated in the HEAT Project over an academic year. Data from six of those teachers are included in this study. These six teachers were purposefully selected as information-rich cases (Patton, 2002) because they participated in both semester sessions across the academic year. The six teachers were also purposefully chosen because they represented each of the six different middle schools within one urban school district in southern Louisiana and had been teaching at their respective school sites for a minimum of 3 years at the time of the study. These teachers were middle-class, female, White, and had teaching experience ranging from 7 to 29 years (teacher information was self-reported).

Each of the participating middle schools receive Title-1 funding, indicating that they are high-needs schools with more than 50% of the student population receiving free or reduced-price lunch. Each of the participating schools is also comprised of student populations that include more than 50% minority (mainly African American) students. Approximately 90% students participating in the HEAT project were African American students.

Data Collection

For the purposes of this research, data collected for this particular portion of the study included interview responses and written reflections from the six participating middle school teachers. Data were collected over two academic semesters, approximately 10 months. Interviews were conducted (a) during and after teacher training, (b) after the teachers' initial meetings/interactions with students in the after-school sessions, and then (c) after the final HEAT competition concluded at the end of the academic semester. Interview questions were informal and conversational and included questions that related to how teachers viewed and perceived students in relation to mathematics ability, motivation, and identity and how the teachers may have changed (in their teaching and/or thinking) throughout the HEAT Project, and their thoughts and feelings about the Project as a whole.

Written responses were also collected throughout the Project. Open-ended reflections about their teaching experiences within the HEAT Project as well as prompts, in which teachers were prompted to reflect upon their most improved students, highest performing students, and on how their participation in the HEAT Project impacted their beliefs about students and their teaching practices, were collected at various points during the Project. This study includes teacher perceptions of African American students participating in the HEAT project.

Data Analysis

Data were analyzed using a qualitative lens. To gain a deep understanding of each teacher's individual responses and reflections and of the teachers' responses as a collective whole, a multiple case study design (Yin, 2015) was utilized to analyze the teachers' perceptions of their students' mathematical abilities, motivations, and learning. For this study, a "case" constituted the written reflections and interview responses of each individual teacher.

This qualitative analysis of the data was further informed by thematic analysis, which consists of searching through the data for patterns and themes, data coding, and the exploration of relationships within and among the categories and thematic ideas (Glesne, 2011). Accordingly, the data were analyzed for themes, coded, individually analyzed, and then analyzed as a "collective case," wherein themes that ran across individual responses were cataloged as representative of the group. Some examples of the themes that emerged from the data include (a) social learning, (b) students becoming experts, (c) teachers as facilitators, (d) low/high teacher expectations, (e) students' confidence/motivation, and (f) identity construction (teacher and student).

Findings and Discussion

The HEAT Project's social, cooperative, constructivist framework incorporates the use of cooperative learning and hands-on materials that invite students to be actively engaged in the learning process. Findings suggest that these processes allowed for

1. Knowledge construction through active, social learning
   a. The creation of enjoyable learning spaces
   b. The creation of supportive mathematics communities of practice in which
      i. Students were viewed/viewed themselves as experts
      ii. Teachers were positioned as facilitators
2. A change in teacher perceptions of students which
   a. Informed student motivation, participation, and learning

Data drawn from teacher interview responses and written reflections suggest that the collaborative, socially focused format of HEAT and the use of the hands-on manipulatives allowed for the creation of a fun and enjoyable learning space that motivated student participation and mathematics learning. In this capacity, HEAT supported student students' knowledge construction by allowing them to learn by "doing" and by engaging them in meaningful and conceptual learning tasks within enjoyable social contexts. Findings of this study further posit that, as they transacted in these ways, students formed mathematical communities of practice that highly influenced their learning and their mathematical identity construction.

Data further suggest that the nontraditional approach to mathematics instruction utilized within the HEAT Project framework was not only successful in yielding mathematical learning but also in positively influencing the ways that teachers viewed and worked with urban, African American students. This shift in teacher perspective facilitated the students' learning and the construction of their positive mathematical identities.

Knowledge Construction Through Active, Social Learning

Students develop their thinking abilities by interacting with other students, adults, and the physical world. HEAT utilizes collaborative learning strategies to increase student motivation and confidence and allows students to participate and grow by creating a supportive social context in which students are able to learn from each other in active ways. In this study, students were motivated to learn because of the active, social nature of the HEAT interactions. Learning occurred as students collaborated and built upon each other's shared knowledge.

Creating enjoyable learning spaces. The HEAT Project format and the use of hands-on manipulatives (game pieces) allowed for a fun, enjoyable environment which, according to the teachers, highly motivated student learning and increased student participation. Teachers also enjoyed teaching students using manipulatives in such a fun way. The hands-on strategy of using the manipulatives and the pictorial representations along with the social nature of the interactions were useful tools for teachers and students alike. Students built knowledge within the competitive, sports/game-like context of HEAT which was supported by the collaborative nature of the Project. According to all six teachers, this nontraditional approach was successful in yielding positive cognitive and affective outcomes.

Teachers responses to participation in the HEAT Project demonstrate how the relaxed, enjoyable, game-like atmosphere created within the Project created an environment conducive to learning. These quotes from teachers demonstrate how this context inspired learning and created an atmosphere driven by motivation (all quotes in this article are derived from the participating six teachers' written reflections and interview responses—names are withheld, student names are pseudonyms):

> Participating with the HEAT Project has created a fun environment in my classroom

> . . . my students love to solve algebraic equations because the approach is like a game

> . . . the students are enjoying solving the algebraic equations, especially the extremely

> long equations, which is something new.

Teachers also noted that their experiences with the HEAT Project have impacted their relationships with students and influenced the ways that they teach:

> . . . it has helped me to form bonds with students in a way I never had an opportunity to

> . . . now I try to make math more fun, with more activities and more manipulatives

> . . . using the manipulatives makes it more enjoyable and really helps them learn

> . . . it is awesome to see students truly excited about math!

These quotes demonstrate the ways that the HEAT Project, and its use of hands-on manipulatives and conceptual learning, created a context in which learning a difficult subject such as algebra was made to be enjoyable. The teachers were confident that the fun, social nature of the algebra practices provided a space in which their students were highly motivated to participate and to learn.

Creating communities of practice. Building upon the enjoyable, collaborative, and active nature of the Project, situated learning combined with social learning theories highlight how the students participating in the HEAT Project created mathematical communities of practice. Confidence was built as students learned, took on "expert" roles, and helped each other within the cooperative and supportive setting provided by HEAT. Students played active roles in their knowledge construction, whereas the teachers acted as facilitators and supported their knowledge-building through hands-on activities, modeling, and scaffolding of student learning.

The following quotes exemplify the ways that HEAT created mathematical communities of practice in which students were socially motivated to learn and to help each other be successful:

> T.J. was my most improved student, who I picked up with only two weeks before the competition. He learned very quickly and was very excited about

> being a part of HEAT. For him, it makes him feel like he is a part of a very elite group of thinkers. Often I can see the pride in his face when he walks into the room or when he talks about HEAT with other students

> Participating in H.E.A.T has given [the students] a boost in confidence. They put forth great effort and have improved attitudes about math

Teachers noted that learning occurred as students collaborated, shared and built upon each other's knowledge, and began to feel like they were a part of a cohesive group. Being a part of a group in this capacity, according to the teachers, improved the "attitudes" of students in relation to learning new mathematic concepts and allowed them to feel that their knowledge was valued, providing further motivation to participate. The HEAT Project embodied the notion that learning and cognition are supported when social interaction and the use of physical objects/actions (manipulatives) combine in cooperative contexts where students are able to actively learn from each other and create a community in which all knowledge is valued and utilized.

Becoming experts. As students formed cohesive groups and constructed mathematical communities of practice, they also began to take on expert roles and to scaffold each other's learning. These quotes from the teachers highlight how becoming experts and helping others was valuable to the mathematical communities of practice that were formed and how taking on these roles helped students to feel as though they were important and valuable players within these community contexts:

> At the beginning, D'Andre had to sit next to a coach and work each problem and have us check it before he would go on. Halfway during the semester, he was working problems on his own and going around helping and tutoring others. It was a great joy to see him in action as a confident and outgoing young man

> Now he works independently and is capable of helping others

> John has a way of solving problems and tutoring others

> Allison teaches others and pretends to be the teacher

As students' confidence grew, so did their participation. As each student realized their own potential, they relied less on teacher input, creating a context in which they were the knowledge-holders. Teachers noted that this aspect of the HEAT Project was highly important to the students' motivation and participation, and consequently to their learning.

Teachers as facilitators. As students took lead roles in The HEAT Project, teachers were positioned as facilitators to enhance and support student learning. Teachers suggested that:

> . . . the work with HEAT has influenced my mathematics teaching because it brought me closer to the way my students see and think about math . . .

Teachers further noted that they were impressed with the ways that students worked cooperatively together during HEAT practices. They felt that their teaching in this context varied greatly from their classroom teaching, in that:

> . . . students shared what they knew, rather than waiting for [the teacher] to tell them all the answers

As facilitators, teachers were able to support and scaffold student learning in ways that positioned students as knowledgeable peers (Vygotsky, 1978) and motivated them to share and to learn.

Adding It Up: Changing Teacher Perceptions and Constructing Positive Mathematics Identities

The authors contend that the most important finding revealed in this study is in the ways that the participating teachers were able to change their deficit-focused views of students and to then support students as they became successful in sharing their knowledge and learning of algebraic concepts.

The following quotes from teachers provide insight into their initial perceptions of these middle schoolers' lack of ability and/or success in algebra and the students' corresponding lack of mathematical confidence:

> . . . math concepts don't come easy for him

> He lacks confidence in math

> Last year his interest/success in math ranged from below average to average . . .

> He lacks confidence when it comes to doing algebra problems

> He is unsure of himself

> She was never seen as one of the stronger students

> He is extremely shy and lacks confidence

> . . . they just don't want to participate or learn

> It is hard for these students to make connections and to learn the concepts

These views are not unique. Urban, African American youth are often confronted with lowered expectations in regard to their mathematical abilities, and these judgments can follow them throughout their academic careers, often negatively impacting their confidence, motivation, mathematical identities, and ultimately, their success in mathematics (Aguirre, Mayfield-Ingram, & Martin, 2013; Boaler, 2002, 2008; Jackson, 2009; Martin, 2000, 2009; Spielhagen, 2011).

Throughout the Project, the teachers' perceptions of the students' abilities, motivation, and confidence shifted:

> . . . they are intrinsically motivated

> Working in HEAT . . . gave me insight on the importance of . . . seeing the students understandings of math and using their math skills in practices

> . . . it is wonderful to see the lightbulbs go off and students actually begin liking math

> . . . participating in HEAT has given her a boost in confidence

> . . . he understands the "math tricks" . . . and began to help other members

> . . . students grew tremendously in their confidence

> . . . the students really understand how to solve the equations

> . . . he even surpassed students who were more advanced than him

> . . . she flourished

> . . . her grades and her confidence are amazing

> This program has done so much for our students in terms of confidence and academics

The teachers' initial perceptions of students were predominantly negative. The data suggest that they overwhelmingly did not believe that the students understood mathematical concepts, thought that they lacked confidence and motivation, and believed that it was "hard for these students to make connections and to learn the concepts." These predeterminations were likely due to the fact that the students' backgrounds and race differed from their own (Martin, 2000). The White teachers from middle-class backgrounds initially believed that the low-income, urban, African American students in their classrooms were generally incapable of high academic achievement and success. These negative assumptions about the skills, abilities, competencies, and motivation of the students, directly affected the ways that they taught these students (with the belief that they would underperform), and the students' mathematical performance thus reproduced these low academic expectations (Ladson-Billings, 2000).

Data further revealed that teachers had shifts in their perceptions of the students. Throughout the Project, the teachers noted how the learning environment framed by the HEAT Project allowed students to be seen through a different lens. As students were called upon to share and build upon their knowledge and learn together, teachers saw a boost in participation, motivation, and understanding. As teachers moved away from the transmission model of teaching and began to create contexts that allowed for relaxed and enjoyable learning and let the students become experts as they worked together in a community of practice, understanding of the concepts was high and students flourished.

Upon completion of the HEAT Project, after a student's team had done particularly well in the competition, one teacher noted that a student poignantly queried, "How you like me now?!" This suggests that the student understood there were initially low teacher expectations for his mathematical capabilities and further suggests that he is now confident in and excited about his mathematical knowledge.

Limitations

As this study uses reflections from six teachers, it is limited in scope. This particular study focused solely on the responses of the participating teachers, therefore, the voices of the students are not included. This is a limitation of the study in that valuing student voices is essential to understanding their mathematical identity construction and their learning. As the HEAT Project is ongoing, these limitations will be addressed in future, more inclusive evaluations and analyses of the Project and its implications.

Implications and Conclusion

Our findings suggest that teachers' instructional behaviors within the HEAT framework along with their perceptions and expectations of urban, African

American middle schoolers' mathematical abilities and motivation interact with students' beliefs and work habits in ways that can promote and support students' positive mathematical identity construction. The social constructivist nature of HEAT allows for student learning, motivation, confidence, and positive mathematical identity creation and counters the notion that urban middle schoolers are not motivated to learn, do not hold valuable mathematical knowledge, and cannot be academically successful in math/algebra.

Implications for future practice include the concepts of valuing student knowledge, positioning students as experts, and providing collaborative spaces for hands-on exploration of algebraic topics as these may support urban, African American students' motivation to participate and be successful in algebra. Correspondingly, the findings suggest that teachers must be cognizant of and evaluate their preconceptions of minority students as deficit perspectives simultaneously incorrectly frame urban, African American students as incapable of learning and negatively influence the way these students are taught mathematics.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This research was supported by U.S. Department of Education Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP) Partnership Grant, PR Award Number P33A140080.

ORCID iD

Tori K. Flint https://orcid.org/0000-0003-3523-7844

References

Aguirre, J., Mayfield-Ingram, K., & Martin, D. (2013). *The impact of identity in K-8 mathematics: Rethinking equity-based practices*. Reston, VA: The National Council of Teachers of Mathematics.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches to teaching and their impact on student learning* (Rev.ed.). Mahwah, NJ: Lawrence Erlbaum.

Boaler, J. (2008). *What's math got to do with it? Helping children learn to love their most hated subject—And why it's important for America*. New York, NY: Viking.

Boaler, J., & Greeno, J. (2000). Identity, agency, and knowing in mathematical worlds. In J. Boaler (Ed.), *Multiple perspective on mathematics teaching and learning* (pp. 45-82). Stamford, CT: Ablex.

Bol, L., & Berry, R. Q., III. (2005). Secondary mathematics teachers' perceptions of the achievement gap. *High School Journal*, *88*, 32-45.

Bonner, E. P. (2014). Investigating practices of highly successful mathematics teachers of traditionally underserved students. *Educational Studies in Mathematics*, *86*, 377-399.

Borenson, H., & Barber, L. W. (2008). The effect of hands-on equations on the learning of Algebra by 6th, 7th and 8th grade inner city students. Retrieved from http://www.source-secure.com/Portals/25/Interim10ReportDec010-2008-6th7th8th-innercity.pdf

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18*, 32-42.

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, *31*, 21-32.

Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1999). *Cognitive psychology and instruction* (3rd ed.). Columbus, OH: Prentice Hall.

Cobb, P., Gresalfi, M., & Hodge, L. L. (2009). An interpretive scheme for analyzing the identities that students develop in mathematics classrooms. *Journal for Research in Mathematics Education*, *40*, 40-68.

Ernest, P. (1994). Social constructivism and the psychology of mathematics education. In P. Ernest (Ed.), *Constructing mathematical knowledge: Epistemology and mathematical education* (pp. 62-71). New York, NY: RoutledgeFalmer.

Glesne, C. (2011). *Becoming qualitative researchers: An introduction* (4th ed.). Boston, MA: Pearson Education.

González, N., Moll, L. C., & Amanti, C. (Eds.). (2006). *Funds of knowledge: Theorizing practices in households, communities, and classrooms*. New York, NY: Routledge.

Greeno, J. G. (1989). *A perspective on thinking*. American Psychological. 44, 134. Washington, DC: American Psychological Association.

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. *Handbook of Educational Psychology*, *77*, 15-46.

Gutstein, E., Lipman, P., Hernandez, P., & de los Reyes, R. (1997). Culturally relevant mathematics teaching in a Mexican American context. *Journal for Research in Mathematics Education*, *28*, 709-737.

Jackson, K. (2009). The social construction of youth and mathematics: The case of a fifth-grade classroom. In D. B. Martin (Ed.), *Mathematics teaching, learning, and liberation in the lives of Black children* (pp. 175-199). New York, NY: Routledge.

Jackson, K., & Wilson, J. (2012). Supporting African-American students' learning of mathematics: A problem of practice. *Urban Education*, *47*, 354-398.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, *32*, 465-491.

Ladson-Billings, G. (1997). It doesn't add up: African-American students' mathematics achievement. *Journal for Research in Mathematics Education*, *28*, 697-708.

Ladson-Billings, G. (2000). Fighting for our lives: Preparing teachers to teach African-American students. *Journal of Teacher Education*, *51*, 206-214.

Lave, J. (1991). Situating learning in communities of practice. *Perspectives on Socially Shared Cognition*, *2*, 63-82.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

Linn, M., Bacon, J. N., Totten, T. L., Bridges, T. L. I., & Jennings, M. E. (2010). Examining teachers' beliefs about African-American male students in a low-performing high school in an African-American school district. *Teachers College Record*, *112*, 289-330.

Martin, D. B. (2000). *Mathematics success and failure among African-American youth: The roles of sociohistorical context, community forces, school influence, and individual agency*. New York, NY: Routledge.

Martin, D. B. (2009). Liberating the production of knowledge about African-American children and mathematics. In D. B. Martin (Ed.), *Mathematics teaching, learning, and liberation in the lives of Black children* (pp. 3-36). New York, NY: Routledge.

McMahon, M. (1997). Social constructivism and the World Wide Web-A paradigm for learning, Conference paper presented at the ASCILITE Conference. *Perth*, Australia. Retrieved from: http://www.ascilite.org/conferences/perth97/papers-index.html

Moses, R. P., & Cobb, C. E. (2001). *Radical equations: Math literacy and civil rights*. Boston, MA: Beacon Press.

National Assessment of Educational Progress. (2015). *2015 mathematics assessments* [Data Files]. Retrieved from https://www.nationsreportcard.gov/reading_math_2015/#mathematics?grade=4

National Research Council (2001). Adding it up: Helping children learn mathematics. In J. Kilpatrick, J. Swafford & B. Findell (Eds.), *Mathematics Learning Study Committee, Center for Education, Division of Behavioral Health and Social Sciences and Education*. Washington, DC: National Academy Press.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: SAGE.

Prawat, R. S., & Floden, R. E. (1994). Philosophical perspectives on constructivist views of learning. *Educational Psychologist*, *29*, 37-48.

Spielhagen, F. R. (2011). *The algebra solution to mathematics reform: Completing the equation*. New York, NY: Teachers College Press.

US Department of Education: National Mathematics Advisory Panel (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

Vygotsky, L. S. (1962). Thought and Word. In L. Vygotsky & E. Hanfmann, G. Vakar (Eds.), *Studies in communication. Thought and language* (pp. 119-153). Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, England: Cambridge University Press.
Wertsch, J. V. (1988). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.
Yin, R. K. (2015). *Case study research: Design and methods* (5th ed.). Thousand Oaks, CA: SAGE.

Author Biographies

Tori K. Flint is an assistant professor in the College of Education at the University of Louisiana at Lafayette. Her research interests include qualitative research and issues of identity in education. Her research further explores issues of equity and access in various contexts.

Peter Sheppard is a professor and Department Head in the Department of Curriculum and Instruction at the University of Louisiana at Lafayette. His research seeks to uncover demonstrable ways to enhance the mathematics schooling experiences of underrepresented groups, so that discussions regarding their cerebral capacity shift from embellishing test score discrepencies to fostering a culture of mathematics excellence.

Nii A. Tackie is an assistant professor in the College of Education at the University of Louisiana at Lafayette. His research interests include core practices for teaching mathematics, math integration in STEM curriculum, student mathematics learning, and teacher preparation.