Restructuring High School Math Learning Spaces with Interactive Technology and Transformative Pedagogy

By

Roland Lucas

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Kenneth Tobin

Date **Chair of Examining Committee**

Anthony Picciano

Date **Executive Officer**

Barry Cherkas

Wesley Pitts

Supervisory Committee

THE CITY UNIVERSITY OF NEW YORK

Abstract

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Adviser: Professor Kenneth Tobin

Worldwide technological capacity is growing exponentially, and in doing so it increases human data search, processing, and sharing capacities. Transnational businesses with local reach are employing leading edge technology tools ever more and are increasingly requiring that their workforce--even low-skilled workers--have competencies for using them. Students can hardly keep up with this exponential growth of data processing speed and knowledge production. I've reached the awareness years ago, that public schools in urban areas fall far short overall in preparing youth to stay abreast of these demands, due in large part to outdated teaching methods and insufficient resources. One indicator that supports this assessment is the ongoing high dropout rate of African American and Latino students in public high schools of which educators and educational leaders are aware.

One means of helping students to adapt to an increasingly technologically demanding market place, is to use interactive technologies infused with the curriculum. Students attending urban public schools, as with most youth today, have already immersed themselves in various new technologies during their activities outside of formal school settings as with social networking through Twitter and Facebook. Leveraging this social and knowledge capital in more formal educational public school settings is one means of enhancing their academic learning experiences

and narrowing the achievement gaps they face. This study focused on what dialogue and learning occurred in a Newark public school math class while students were in a culturally-empowering learning space that utilized advanced interactive technologies, coupled with liberating ideologies embedded in the curriculum. The math activities were contextualized within and linked to the broader communities students come from, rather than abstracted from their communities. The students accessed and managed available sociocultural and technological resources to construct meaning and knowledge applicable to their collective self identified community issues and motives. It has my been experience throughout the course of this study that such an environment produces educational experiences for minority students that are transformative of existing constraining structures in public schools, affording agency for disadvantaged groups. This result can in turn close the knowledge and achievement gaps they face.

Dedicated to: My students and the diaspora of underserved communities.

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Multi Level and Relational Perspectives

The Urgency of the Matter

Just as technological innovation increases exponentially, so does its impact on society. There is a growing divide between the technological advances in and demands of society and the ability of minority students in public schools, particularly African American and Latino students, to match those advances and demands. One indicator that supports this assessment is the ongoing high dropout rate of African American and Latino students in public high schools, as is the case in New York City. Most educators and academics are aware of this stark reality. Gary Orfield (2004, p. 2) reports the following graduation facts for all public schools in New York City:

Table 1.1
New York City High School Dropout Comparisons

For every 100 from each subgroup of:	Total that graduate from high school	Females that graduate from high school	Males that graduate from high school
Whites starting from kindergarten	75	77	71
African-Americans starting from kindergarten	35	39	29
Latinos starting kindergarten	32	35	29

According to the "Scott 50 State Report on Public Education and Black Males - 2012", "In 2009-10 the national graduation rate for Black male students was 52%. The

graduation rate for White, non-Latino males was 78%. This is the first year that more than half of the nation's Black males in 9th grade graduated with regular diplomas four years later. The national Black/White male graduation gap, however, only decreased by 3 percentage points over nearly the last decade to 26 percentage points." (p. 13) These statistics indicate that the knowledge and achievement gaps between Whites and other minorities, (particularly Blacks and Latinos) remains intransient for the most part. An urgent response and new initiatives are needed to close these gaps.

There is a real danger that African Americans and other minority groups will become a permanent underclass that is unable to compete with other groups, if the knowledge and achievement gaps continue to widen. It is vital for African Americans, Latinos, and other minorities to demand and devise educational programs that utilize advanced technologies to accelerate their technical knowledge, forming a basis for attainment of their educational and societal goals.

One means of accelerating the closure of the achievement gap in public education is through interactive technologies backed by a culturally sensitive pedagogy. My project is to model such a learning environment that can be generally replicated in public schools where African Americans predominate. If educators can learn how to improve education for African American students in public schools significantly, they will have learned how to improve education for all students in public schools. The sooner the achievement gap closes, the closer the United States will be to producing a truly pluralistic society where all are capable of meeting the demands of a modern world.

Relations between Culture, Education, and Social Transformation

To assess public school policy and praxis, it is essential first to place the school in the context of the wider sociocultural field in which it is situated. Learning activities in any school setting are mediated by the macro and meso structures that surround the schools. Schools are primary sites for the reproduction of larger cultural values and motives, which often have much to do with reinforcing a stratified system of power relations. These macro and meso structures will deeply shape the educational practices, experiences, and outcomes that occur.

Pierre Bourdieu (2000) intimates in his works that schools are sites where the reproduction of the structure of power relationships between social classes occurs. This happens through the mechanisms of distribution of cultural capital. Implicating educational systems as such, Bourdieu (2000) says,

> [t]his means that our object becomes the production of the habitus, that system of dispositions which acts as a mediation between structures and practice; more specifically, it becomes necessary to study the laws that determine the tendency of structures to reproduce themselves by producing agents endowed with the system of predispositions which is capable of engendering practices adapted to the structures and thereby contributing to the reproduction of the structures. (pp. 56-68)

One idea embedded within this statement is the actions a person may perform are tied up with an engagement of structures (engendering practices), which can lead to a reproduction of existing structures. This suggests there must also be another side to the coin; agents can engage even the most limiting elements of structures, and positively

transform them to be more in line with their own goals. My research considers this prospect in its attempt to use technology resources to support progressive educational praxis for African American and Latino youth in public schools.

It is commonplace for those within a society who benefit from the distribution of resources which is stratified along racial and class categories, to deny the reality that racism and classism still deeply impinge on the learning outcomes and potential of minority students in public education. This denial serves the purpose of maintaining these limiting structures and shielding these structures from macro- and meso-level transformation. Bell hooks (1994), references the need to transform educational institutions into sites of liberation:

> If we examine the traditional role of the university in the pursuit of truth and the sharing of knowledge and information, (resources), it is painfully clear that biases that uphold and maintain white supremacy, imperialism, sexism and racism have distorted education so that it is no longer about the practice of freedom. …The call for a recognition of cultural diversity, a rethinking of ways of knowing, a deconstruction of old epistemologies, and the concomitant demand that there be a transformation in our classrooms, in how we teach and what we teach, has been a necessary revolution – one that seeks to restore life to a corrupt and dying academy. (p. 29)

Racism is not the only force to be reckoned with. Classism, excessive capitalism expressed through globalization and manifested structurally in local schools down to the level of what gets taught in classrooms, is also a force in need of transformation. In this study I stress that macro-level organizational structures impinge on local urban school structures. They limit the educational outcomes and potential of most minority students.

Tobin (2010, p. 140) asks, "How should access and appropriation of resources be included in a theory of freedom in science (any) education?" Asking how technology resources can be accessed and appropriated in culturally empowering ways to help these groups reach their goals extends this question posed by Tobin. This study began by proposing that collaborative spaces using interactive technologies can enhance learning for minority students, if those spaces are constructed in culturally empowering ways that take up the challenge of developing positive student identities as agents for personal and collective uplift.

Emerging Role as a Teacher Researcher

As I progressed through the Urban Education doctoral program at CUNY, I was not quick to define myself as a researcher of any particular stripe, not wanting to limit my inquiry by that definition. I was more focused figuring out how to develop practices that will increase the chances of my students reaching their higher educational goals and developing their identities as emerging scholars and professionals. Yet, by being with and learning from both seasoned and emerging researchers, I grew comfortable with assuming the qualification of teacher researcher. It describes much of my goals for and positioning with my students in urban schools. So the label fits my activity, rather than me trying to conform my activity to a label.

The type of research I've conducted in my classroom can be viewed under the purview of qualitative research, and ethnography, while having a phenomenological and hermeneutical approach to inquiry. The overarching aim of this study has been to create culturally empowering learning spaces where interactive technologies are leveraged to enhance learning on the behalf of students, particularly African American and Latino

students. The Yvonna Lincoln and Egon Guba research authenticity criteria (1989) have been used throughout my research. The research groups under the tutelage of Ken Tobin at CUNY, which I've been a part of, use it widely. The Lincoln and Guba authenticity criteria is a system for judging interpretive ethnographic research and overall, stresses that the importance of conducting research that benefits those who are involved. Nicole Grimes (Murphy and Scantlebury, 2010), a doctoral graduate of CUNY's Urban Education program, summarized the Lincoln and Guba criteria as being:

> [o]ntological, educative, catalytic, and tactical authenticity. Ontological authenticity refers to the ways in which participants enhance their own constructions of social life as it relates to what they have learned from a study. Educative authenticity represents the extent to which stakeholders, particularly those outside the research group, understand the implications and nuances that emerge from the study and the standpoints of key stakeholders. Catalytic authenticity relates to the obligation of the research and researchers to create ways to expand the agency and catalyze positive changes of all stakeholders involved in the research. Finally, tactical authenticity refers to the extent to which stakeholders have agency to bring about the change they desire and benefit from what has been learned from the research (p. 209).

In keeping with the Lincoln and Guba authenticity criteria, I view the merit and benefit of my study as being based on how well answers to the essential questions posed in this study can shed light on whether or not an empowering learning space has taken form. Ultimately the participants and stakeholders of the study must determine if this is so. The findings of my study would be available to help them make this determination.

The rationale for posing the essential questions of this study is that students' achievement must be assessed in relation to their developing identity, critical sense, knowledge construction towards self-relevant problems, and developing agency to achieve individual goals and community motives. A synthesis of ideas from the various cultural theories mentioned in this study will afford a deep understanding of the processes of meaning making, and growing agency of participants to appropriate resources (including interactive technologies) for the purpose of advancing the goals of students and the motives of the communities they come from. Below are the essential questions posed in this study along with the corresponding authenticity and validity checks used for them.

The first essential question is how, if at all**,** do these students' discourses and authored products express the development of their ideological self, privileging their own "voices"; meaning their own ideas of what learning activities will benefit them and their identity groups? This question is meant to ascertain if students feel free to counter ideologies and structures that impinge on their agency in education. So the first authenticity check for this study is that students will experience an expansion of their own "voices" to express what knowledge and activities are beneficial for them. They will be less likely to accept and follow uncritically, ideas and practices that do not serve their own defined criteria for what benefits their self-defined goals.

The second essential question is how, if at all, do these students' discourses and authored products express development of their affective identities as competent actors in their semiotic domain? This question builds on the first and tracks the students' agency to proactively appropriate resources as needed to accomplish their individual goals. The second authenticity check for this study is, students will increasingly identify their

constructed knowledge and activities as enhancing their math competency. Local stakeholders in the school and students' communities will likewise identify the collective praxis of participants as establishing an educational paradigm that actually supports educational objectives aligned to the enduring best interests of students.

The third essential question is how, if at all, do these students' discourses and authored products express that they identify their problem solving activities and goals as advancing the motives of their group and larger community? This question examines if students associate their individual agency with the goals of their wider group, family, and community. A third authenticity check for this study is that students' constructed knowledge and activities actually serve to transform existing educational practice on not only local levels, such as classroom and school, but even on, meso levels such as district and region. The discourses and knowledge produced while using interactive technologies remain directly relevant or attuned to the common problems faced by the identity groups of the student and would have the potential to redress those problems. Furthermore, the established praxis captured by this study would serve as a model for transformative education on macro levels, as in urban education for minorities across districts, states and throughout the entire country. If this transformation does not occur after implementation across departments in a given school for several consecutive years, despite being fully resourced materially and by supportive ideological perspectives from educators, then the study must be reevaluated as to its benefit to students.

Epistemological Stance and Methodologies of a Teacher Researcher

I'm coming to an increasing awareness that there are traditions and communities of teacher researchers. Marilyn Cochran and Susan Lytle (1999) identify major

conceptual frameworks that have emerged in the 90s and continue to shape teacher researcher methodologies and methods today. I see my research as correlating strongly with two of them: teacher research as social inquiry and teacher research as ways of knowing. These conceptual frameworks are not mutually exclusive. The two have shared implications for educational practices, particularly for those in schools with underprivileged students. Cochran and Lytle (1999, p. 17) say of teacher research as a social inquiry concept, "The emphasis here is on professional education that is about posing, not just answering, questions, interrogating one's own and other's practices and assumptions, and making classrooms sites for inquiry – that is, learning how to teach and improve one's teaching by collecting and analyzing the "data" of daily life in schools." The questions I've posed in my research are to be answered by interrogating the impact of leveraging interactive technologies to achieve student's goals. For me, this advances my role of teacher to that of an agent for change.

Teacher As Agent For Students' Educational Goals and Social Change

Referring to the emergent trend of action research of the 90s, Cochran and Lytle (1999, p. 18) say, "This work is grounded in critical social theory and aimed explicitly at social change …The emphasis is on transforming educational theory and practice toward emancipatory ends and thus raising fundamental questions about curriculum, teacher's roles, and the ends as well as the means of schooling." I see my role of teacher researcher in this vein. In my role as researcher, I am seeking to change existing practices and power relations that constrain students' lifeworlds. I advocate for social change, raising students' awareness of unequal power relations and encouraging them to analyze structures that reproduce their subordinate roles in society. Doing so, I think, teaches

students how not to become complicit in their own subordination. The teacher researcher for me is not devoid of an activist stance as an agent for change. The canonical content knowledge to which I expose my students is always presented as a resource that students can use to solve problems that are relevant to their lifeworlds. Math content knowledge is not offered up as an abstraction from students' own experiences. This requires an active negotiation as the teacher researcher to continually make canonical math relevant to students' lifeworlds. It is not enough to claim to be an objective observer who has an insider track on an experiment involving students. This would not be in keeping with my activist stance and the authenticity criteria. Rather, classroom research for me must have as a goal, outcomes that will directly benefit my students.

Alignment of Goals

It is important for teacher researchers to have a reflexive disposition to manage and balance the goals of teachers and students. Students don't always know how to go about achieving what is best for them, but they will always know what is best for them when they see it. Students may not be aware of the wider implications of their actions and how their action may make them complicit with constraining structures. The teacher must encourage students' authorial voices and co-construct knowledge rather than simply repeat existing knowledge that is remote and abstract in relation to students' lifeworlds. The teacher must guide students to realize their individual and collective goals.

For many disciplines taught in schools, there is a plethora of interactive technology tools that can be used to enhance learning. These ways have a lot in common with how students use virtual social media to develop their social lives. Students' social media competencies can be leveraged to help them reach their higher educational goals.

My larger argument is that the cultural practices in classrooms should not be abstracted from students' lifeworlds. Rather, the cultural competencies students bring from fields outside of the classroom should be incorporated and leveraged to attain students' educational goals. The validity of my research is in the actualization of this overarching goal as a teacher researcher. These goals are consistent with what Cochran and Lytle (1999, p. 18) have laid out as a "larger argument for social inquiry as a new paradigm that aims frontally to transform rather than describe school or classroom settings as do classic ethnography and some other branches of qualitative research."

Inquiry as Ways of Knowing

Another major trend of the 90s that Cochran and Lytle (1999, p. 18) summarize is teacher researcher as ways of knowing, which "pays particular attention to the discourse of learning communities, the conjoined efforts of teachers and students as inquirers … The emphasis here is on blurring the boundaries of research and practice and on conceptualizing practice as a critical and theory-building process." My epistemological stance is that teaching must be aimed at not only covering content knowledge or formal knowledge, but also on discovering ways of applying that knowledge to solving problems relevant to students' lifeworlds. The goal is to help students develop new dispositions, competencies and practices that are relevant and applicable to their lifeworlds. There has to be a mindfulness of the existing structures that tend to reproduce outcomes that limit student life chances. These structures are not necessarily external to students or teachers. They have become internalized and become the habitus of both students and teachers. Critical to the role of teacher researcher who has these agentic goals, is to frequently reflect on existing practices, and evaluate how existing practices either aid or hinder

students reaching their individual and collective goals. Many of these limiting cultural practices are enacted in unconscious ways that tend to reproduce dominant structures. It is crucial to change that habitus, embodied by both students and teachers. For teacher researchers this must be an active, purposeful and mindful activity. This is not easy, because these old dispositions have been positively reinforced or sanctioned by powerful forces that can seem beyond the teacher's sphere of control. However, there will always be available a third space, between the dominant structures, that are opportunities to develop different practices that flow from a different conditioning. While it may be true that we do not always control what others do and the production of limiting structures at play in schools, we always can control how we respond to them as willful human beings. It is a matter of mindfulness of how we choose to respond. The constructive changes in teacher dispositions will inevitably reflect in constructive changes in students' dispositions, and that is essential for building a movement for better education from the ground up.

Stakeholder Solidarity

For me an important aspect of my practice is that it does not remain local. I seek to have an influence on not only the other teachers in my department, but also teachers in the entire school and district. In addition, I am trying to not only enable students to increase their math fluency in this class, but I hope the dispositions that they develop to succeed in math, will carry over to all the fields of their lives; and that students will in turn help elevate their communities. This is a larger goal I am striving for as a teacher researcher. How can I co-create enduring practices that cascade beyond my classroom to

help students reach their goals and competently support the wider motives of their communities?

One of the roles of a teacher researcher is to expand his/her reach beyond the classroom by working with other stakeholders who are vested critically to train students to reach their self-defined goals and circumvent constraining structures. As Cochran and Lytle (1999, p. 18) put it, "The larger goal is to create classrooms and schools where rich learning opportunities increase students' life chances and to alter the culture of teaching by altering the relations of power in schools and universities." Teachers should be aware of practices that are adaptable / transferable into wider contexts and can be adapted in ways that are meaningful in specific circumstances. This becomes a basis of a theoretical framework and methodologies for teachers in urban schools. So what becomes the object of teacher researcher is not only the culture enacted by students in interplay with other students and the teacher, but also of the teacher researcher in interplay between the culture of students and the culture of the administrative structure as well as the structures of the wider society in which the school is embedded. The catalog of knowledge produced from teacher researchers acting in solidarity becomes a resource for a larger movement of social change. As Cochran and Lytle (1999, p. 18) put it, "Fundamental to our notion of inquiry as stance is the idea that the work of inquiry communities is both social and political – that is, it involves making problematic the current arrangements of schooling; the ways knowledge is constructed, evaluated, and used; and teachers' individual and collective roles in bringing about change."

The teacher researcher does not remain localized in his/her awareness and aims. This scope of awareness places the teacher researcher in a wider field, particularly when

the teacher researcher becomes associated with other stakeholders who are of like mind and like goals. The teacher researcher's methodologies, methods and practices become structures that are useful to a wider community of members who are interested in transforming education for students in ways that help them reach their individually self defined goals and wider collective motives. In my research on using interactive technologies to enhance student learning, I have managed to generate a higher interest in this approach not only in my math department, but also in other schools in my district. It is important to ensure not only the use of interactive technologies in wider organizational units, but to use them for the purpose of increasing student co-authorship and authorial voice, for building student competencies that are aligned with their individual and collective goals.

Chapter 2

Multi-Theoretical Framework

A basis for this study is Mikhail Bakhtin's theory (Bakhtin, 1981) on dialogical discourse and "ideological becoming" to envision processes of positive collective identity development through collaborative discourses and knowledge construction that can take place in culturally empowering learning spaces. The theories and analyses of Bourdieu, Tobin, and Turner relating to multi-level sociocultural structures support a vision of social transformation and have played an important role in the construction of this study. Any research addressing the transformation of educational praxis must be grounded in a sociocultural theory of action that accounts for the structures of the school environment as being embedded in larger cultural structures. It must also consider the motives of the groups involved and the dynamics of social change.

Bakhtin's Dialogical Discourse and Identity Development

Agency involves an actor using available tools, structures, or resources to carry out actions to reach a goal. My unit of analysis is not the agency of African American students as individuals themselves. Too often this kind of focus produces deficit theories, finding the problem of under-achievement by African American students in their attitudes, minds, and ethnic culture. It is not the African American student in isolation, even while connected to advanced tutorial software applications that the study focuses on. Instead it focuses on activities of groups of students in collaboration through interactive technologies for the purpose of increasing their agency to offset much of the limiting structures of racism and classism as manifested in their local communities. At

issue here is how through their collective activities while using interactive technologies, such students can proactively solve problems that are relevant to their group and to their communities.

Furthermore, collaborations in networked learning spaces involving a community of students tend to make the construction of knowledge less centered on the adult teacher as the only source of valid knowledge—less an exercise of reproducing established knowledge and power structures. That is, knowledge production in interactive environments would be less authoritative, monological, and passive, as Bakhtin (1986; 2004) describes it. The educational dialogue would rather be more in keeping with Bakhtin's concept of inner persuasive discourse where participants actively scrutinize, challenge, change, reject, and argue over existing knowledge to suit their needs and evolving understandings. Multiple utterances or dialogues are then considered, synthesized or otherwise reshaped as needed (polyphony). New products that students appropriate and generate can be acted upon to support their agency and identity formation. Existing knowledge and relational structures will be reproduced only if these structures support the motives of the collective. If they do not, these structures should be targeted for transformation, thus providing for student agency and liberation education.

Students would no longer fall into serving the intentions of dominant groups nor channel the words, ideologies, goals, and problems of those dominant groups. Students could become critical thinkers in direct proportion to how they problem solve for the uplift of their communities (reaching common community goals) not just in their ability to analyze data and problems. Without this directed critical facility, students would simply implicate themselves in sustaining the reproduction of their own subordination in

society through a mis-educational system. Students would recite by heart other people's voices or structural rules, and in the Bakhtinian sense, parrot authoritative discourses, rather than retell their stories in their own words. Learning to privilege one's own critical voice is what Bakhtin (1981) refers to as "ideologically becoming." This approach to educational dialogue would encourage critical thinking and development of a voice or ideological self. It is also in keeping with a culturally sensitive approach to education that respects difference and builds upon the life experiences of students. It would furthermore facilitate sharing with and building upon ideas of others to achieve common motives, or community uplift.

Extending James Gee's Ideas On What Video Games Teach About Learning

It is my experience, as an educator and an African American / Latino who has gone through the public education system in New York City, that African American students in public education view themselves and are treated externally as a diaspora or affinity group that has a different set of challenges and, consequently, a different set of immediate goals than other student groups. James Gee (2007, p. 19) describes *semiotic domain* as "any set of practices that recruits one or more modalities (e.g., oral written language, images, equations, symbols, sounds, gestures, graphs, artifacts, etc.), to communicate distinctive types of meaning." I extend the definition of *semiotic domain* to refer to the various disciplines taught in schools, though my focus is on the situation of African American and Latino students in the mathematics semiotic domains. For Gee an affinity group is simply any group associated with a particular semiotic domain. I refer to the subset of African American and Latino students who are situated in urban public schools and who generally struggle with math as an affinity group. I principally target

this affinity in my study. Sometimes I focus specifically on the African American affinity group due to its unique ethnic history and experience. However, in most cases what I say for African American students in urban settings is extended to Latino and other minority students.

The legacy of institutionalized racism as manifested in the public education of minority students specifically and in society generally has contributed to the formation of the African American student affinity group, for example, that is set apart from normalized groups. As I say this, a memory comes to mind of how groups sat in the cafeteria at the college I attended, Westfield State University in Massachusetts, which was 95% White, 3% Black and 2% Asian or other. (Note that I use the uppercase B when referring to Blacks, as this reference is not to a color, but to a broad ethnic group). Blacks always sat together and apart, behaving like an affinity group. For four years this type of behavior exemplified for me the collective disposition of the African American minority group situated in the wider educational arena of this country. It's worth noting here that every individual and group has its own ethos and ideologies, hence its own measures, modes and means of collective achievement. I see achievement as the attainment of knowledge and the development of competencies, or habitus in the Bourdieusian sense, necessary to produce structures that will enable individuals to successfully reach their goals, and to support the motives of the groups with which the individual identifies (i.e., Gee's identity groups).

It is worth investigating how African American students located in economically depressed urban areas see themselves in the context of the public education system. Though this inquiry is germane to the topic of this study and touches on Gee's *identity*

*principle (*Gee, 2007) a review of attitudes that shape the African American student's self-perception is not given here. I do agree with Boykin's "triple quandary" and Dubois' "double consciousness" as concepts that illuminate general dispositions of African Americans in the context of the public education system. I focus on the issue of how this affinity group (and by extension the Latino affinity group) can utilize current technologies effectively to close the knowledge and achievement gaps it faces. Tied directly to this is the inquiry into practices that can promote the positive identity development of African American students as doers of mathematics.

Affinity Groups and Math Identity

Gee (2007, p. 59) talks about how members of an affinity group can enter a semiotic domain with performance weakness, therefore needing a "psychosocial moratorium," which he describes as "a learning space in which the learner can take risks where real-world consequences are lowered." Applying this concept to the subset of African American math students in urban public schools, teachers of these students must not only be sensitive to the academic weaknesses they bring to math classes but also effectively use methods that can mediate the complexities of math problems that often defeat weaker students. This is where the use of technology in the classroom can be a vital asset. First, however, there needs to be an understanding that education in large part has to do with identity construction and the building up of self esteem or self efficacy.

With African American students, who may have developed oppositional attitudes to public education generally due to their experience of various forms of racism in society, it is vital to address these attitudes in positive ways, starting with an acknowledgment of the prevailing structures of racism experienced by students. The

teacher must encourage the development of a constructive and engaged projective identity capable of transcending student conditioned responses to racism and the structures of racism themselves in the students' environment. Gee (2007, p. 55) says, "Without such an identity commitment, no deep learning can occur. The student will not invest the time, effort, and committed engagement that active, critical learning requires." Once students are on the path of developing a healthy projective identity, believing that they can learn the subject at hand, it is then vital to reinforce this identity formation by scaffolding methods.

Mathematics Identity Building In a High School Class

In preparing my Algebra 2 classes to take the New Jersey state standardized high school proficiency exam in mathematics, I make heavy use of graphing utilities such as a graphing calculator and math modeling software applications such as Geometer's Sketchpad and Maple. Though I teach my students how to handle challenging questions about functions and their graphs analytically or by-hand, I frequently reinforce a specific concept by using the graphing utility. Sometimes I may even present the concept with the graphing tool first. The reasons for this are both several and critical. My students tend to be more receptive to visual representations of a problem and its solution as opposed to simple text representations. In my view, teachers should embrace multiple approaches to teaching students in need of remediation. Gee (2007, p. 224) refers to this as the "multimodal principle," where "meaning and knowledge are built up through various modalities (images, texts, symbols, interactions, abstract design, sound etc.), not just words." This is not to imply that African American students or any other group cannot master textual representations as well.

I've taught in Newark public high schools for the past 7 years. The majority of my students do tend to have weaknesses in analytical problem solving. Graphing utilities, such as those I mentioned, scaffold around those weaknesses, thus providing the immediate satisfaction to students of understanding and solving the problem at hand. The class can then spend more time talking about the solution and its potential value or relevance to them. Once they are aware of the graphical solution and its possible value to them, it is then easier for me to sell them on the value of knowing how to handle the same problem analytically. They also trust that I will successfully guide them to the by-hand solution, as I have already done with the graphing tool.

Through scaffolding, students are able, for example, to bypass having the adeptness of graphing functions by-hand and analytically solving for unknowns, by simply entering the function definitions into a graphing utility and displaying the results. The various attributes of the function can be readily known by visual inspection (such as critical points, local maxima/minima, asymptotes, tail end behavior, domain, range, undefined points, inflection points, roots, and intersections with other functions to solve for an unknown) with relative ease, compared to discovering them analytically. Shielding students from undue complexities affords them more time to engage in higher-ordered thinking and the thrill of solving more complex problems, thus boosting their sense of self-efficacy. This speaks to Gee's (2007) concept of "psychosocial moratorium," where success is not dependent on managing all the complexities of a problem at once.

The above approach exposes students to the sphere of higher-ordered thinking as it relates to the math semiotic domain. Student weaknesses can then be addressed from a position of gleaning the big picture, increased engagement, self-confidence, and self-

motivation, all translating into progressive achievement. Gee (2007, p. 40) sums up the positive effects of applying good gaming principles to education when he says, "they situate meaning in a multimodal space through embodied experiences to solve problems and reflect on the intricacies of the design of imagined worlds and the design of both real and imagined social relationships and identities in the modern world." What this implies, as it relates to the unique learning needs of African American students in math, is that we must empower them to be active doers of math in these creative learning spaces. For this to be accomplished, weaker math students must engage in math that is relevant to the unique challenges they face in both the education realm and the larger society. These learning spaces must actively prepare them to be critical thinkers and to solve the specific problems they experience. Throughout this process it is critical for instructors to be consciously aware that education is certainly deeply involved with identity construction. This study has revealed that with the above approach, increased student engagement and willingness to work through math problems is likely.

Leveraging Cultural Capital

> "I want you to know that we as a people will get to the promise land."
> (Martin Luther King, Jr.)

The above statement is an affirmation that African Americans see themselves as a unique ethnic collective, having distinct historical experiences, ways of knowing, ways of being, values, problem sets, and goals, that are not in total the same as other collectives. This unique ethnic history must be considered if the education system is to reach and teach African American students, especially in schools where they predominate such as urban schools. Ladson-Billings (1994, p. 134) expresses this by saying, "Without greater

exposure to the students' culture teachers lack the tools with which to make sense of much that transpires in the classroom." I interpret this reference to "students' culture" to mean the ethos or historical experiences and ideologies shared by the student with others of like ethnicity. The ethos shared by students does shape how they approach and navigate learning. However, throughout this dissertation culture has the meaning given by Tobin (2006):

> Culture comes to be enacted in the form of practices and associated schema that members bring to salient issues. In the process, they exercise their agency (i.e. power to act) as part of which they appropriate the structures of a field to simultaneously meet their personal goals (teaching a science concept) and the collective's motives (the schooling of new generations). (p. 15)

This study focuses on the culture that is enacted and produced when students are engaged with math problem solving while using interactive technologies. Through positive sanctions and re-enforcement by educators and students themselves these activities can develop into lasting dispositions on the part of students, and into teaching praxis for teachers that support students' self defined goals. Considering their unique ethnic identity, it follows that not only must the methods of teaching African American students be appropriate for this group but also the goals, short term and long term, of teaching African American students must be viewed as a basis of their education. Further emphasizing this point, Geneva (2000, p. 21) has said, "Teaching is a contextual and situational process. As such, it is most effective when ecological factors, such as prior experiences, community settings, cultural backgrounds, and ethnic identities of teachers and students are included in its implementation." This is a basis for my belief that

pedagogy and curricula must be designed to address the needs of schools where African American students predominate. It must be designed in culturally sensitive ways that address the unique learning styles, ideologies and goals of African American students. With this imperative in mind, it then becomes vital that teachers be trained to teach with this sensitivity to ethnic historical experience. This requires that teachers are given training and a directive to do so; without which it is by no means a likelihood to occur, since most teachers of African American students come from a ethnic background different from their students and lack familiarity with the ethnic historical experience of African American students. Even when the ethnic backgrounds of teachers and students are similar, it is not a given that teachers will deliver the curriculum and instruction with sensitivity to ethnic experience, because many African Americans teach in the way they were taught, i.e., often from a Eurocentric perspective.

As things stand now, education in schools with a predominately African American student body takes on a much different directive and accomplishes not the students' goals but largely a reproduction of existing unequal power relations. This reality is made manifest through various means. Martin (2007) helps conceptualize some of the ways that this occurs when he addresses the question, "*Who should teach mathematics to African American children?"* He states*,*

> I claim that the manner in which this question is addressed in mainstream research and policy contexts is largely a function of (a) the simplistic ways in which the aims and goals of mathematics education for African American children are framed (i.e., closing the so-called racial achievement gap, increasing course enrollments, preparing students for the workforce) and (b) the problematic ways

> in which African American children are socially constructed as learners with particular kinds of deficiencies in relation to students who are identified as white and Asian. (p. 21)

In answering the question of who should teach mathematics to African American students, Danny Bernard Martin (2007) makes the argument that they should be people who have sensitivity to the learning styles and goals of African American students, and I agree. He notes, "for me, teacher dispositions, racial competence, and commitment to anti-oppressive and anti-racist teaching are just as important as knowledge of subject matter; a teacher who is truly highly qualified must demonstrate competence in all of these." In some cases this ethnic sensitivity will be a natural outgrowth of teachers having the same ethnic background as their students. Yet having the same ethnicity does not guarantee that a teacher knows how to teach in ways sensitive to students' ethnic backgrounds.

In most cases teachers do not have this sensitivity and require training in how to teach African American students through leveraging their existing cultural capital. It is my view that it is not enough for teachers to learn how to speak the code language of African American students and act like "they are down" with the kids, though this can be a great aid. It's not enough to have teachers with strong content knowledge and pedagogical skills, though this too is essential. Teachers must be aware of the socioeconomic realities, pressures, ideologies, and structures that limit the life opportunities of African American students. They must be willing to conspire against these structures along with the students and develop counter structures that promote student agency. Teachers must be willing to organize the curriculum and instruction to

help African American students engage these structures in agentic ways to help them reach their self-defined goals. Educators must uncover the aspirations of African American students and, given the obstructions they face, to fulfill those aspirations. This approach should be reflected in lessons taught on a regular basis. It should form the praxis of teaching for liberation and preparation for the demands of a twenty-first century global economy. There must be recognition that this kind of teaching, as with any, is deeply implicated in the identity formation of students as competent managers of knowledge capital and other resources to meet the collective goals of their communities. Any teacher who is willing and prepared to do this kind of teaching is qualified to teach African American students.

Discourse on Difference

The conceptual context and theoretical perspective(s) of Thea Renda Abu El-Haj (2006) relate strongly to my research interests and, I think, is an exemplar of the culturally sensitive training material, which I think teacher education programs should require. The following captures her understanding of difference:

> Focusing on differences that make a difference in education as if they were located in the particular bodies/groups, rather than in the relationships of difference created by the arrangement of institutions – relationships that are political in the most fundamental sense that they produce distributions of power – is dangerous. It tends to lead us to wonder about either the "deficits" or the particular needs of some groups of people and not see the power afforded by reigning practices of schools and society, to people who are not

> marked different. … Difference is best understood as a marker of political relationships set up through everyday institutional practices. (p. 198)

One key viewpoint taken up by the author is that the relationship between discourse, practice and power is an essential one for enacting social action and change. In this view, discourse about difference can structure possibilities for action. Educators facilitate the capacity of students to participate fully, and to contribute meaningfully to all its activities. Educational justice, a major educational goal where minorities are involved, is realized when educators respect the moral equivalence of all people.

Another key theoretical perspective promoted by El-Haj is need for educators to have a relational view of difference. From a relational view, individuals and group differences become a "problem" only in relationship to existing routines, norms, and values opens up the possibility for creating classrooms and schools that are just. At the heart of her view of educational justice rests a relational understanding of difference.

El-Haj also promotes the concept of "recognition" where educators foster having student group affiliations fully acknowledged, included and equally valued as an essential component of a fair and just education. Recognition acts as a corrective to the exclusion wrought by refusing to see differences – differences that entail values, norms, knowledge, and experiences. This has ramifications for existing biases in standardized testing.

I see the applicability of all these concepts as relevant to my research interests. Examination of the relationship between discourse, practice, and power is a key for enacting social action and change. Discourse about difference can structure possibilities for action. A relational view of difference will relate the problem sets of African Americans to the historical context of oppression (racism). It will reveal how those

historical patterns continue to limit current educational possibilities for African Americans, as played out in macro socio-eco-political structures in which public schools are situated in. A relational view will show that just as African Americans have been targeted as a collective for oppression (slavery, Jim Crow, institutionalized racism) in ways that have limited their educational opportunities, so, too, must they be targeted as a collective with new liberating structures to remedy the damage caused by persisting limiting structures. My conception of networked learning spaces targeting African Americans and Latinos is such a remedy. Its benefits will, I am convinced, be felt widely and deeply throughout the country, as equality for one is equality for all.

African Americans have a problem set different from those of other groups due largely to the effects of racism past and present. Those problems should be recognized and dealt with aggressively. The social justice and pedagogical themes raised by El-Haj are the same themes raised in this study; however I have taken them a step further by acknowledging the powerful impact which the harnessing of advanced technologies in the service of educational enhancement has in advancing the collective learning goals of African Americans and other minorities.

I embrace a frame of analysis and the development of praxis that serves to empower African American (and by extension other minority students) students to reach their individual goals and collective motives. This is not to say there is just one goal that can be identified; nor is it to say any one person can speak for the entire African American collective. Most people can use their natural powers of perception to recognize what is empowering and what is not. Recognizing the benefits of culturally sensitive pedagogy and curricula is not hard to do. What is hard is mobilizing the will to bring it

into practice and praxis in the face of strong opposing ideological winds of oppressive power structures that serve an opposing motive. Along with these oppressive power structures and motive forces, are frames of analysis and constraining pedagogical practices that tend to reproduce power differentials in education, reaching down into the level of the classroom. These structures have to be exposed, circumvented, or otherwise countered with structures, resources, and praxis that provide agency for African Americans to achieve their self-defined goals. There is no one approach, method, or program that provides this agency. However, training with exemplar methods, practices, tools, and techniques to provide this agency is essential for teachers of every background.

Attributes of Empowering Pedagogy That Leverages Cultural Capital

There are some essentials that must span any serious praxis of teaching with sensitivity to the ethnic historical experiences of students. Chief among these is incorporating collaborative instruction that is relevant to students and to the communities they come from. Students must be taught both in proven and in novel ways to apply what they learn in school to solving the real problems of development faced by their communities. They must be taught how to work collectively to achieve collective goals of their communities. This is a skill just as solving an algebraic problem is a skill. Mathematics must be taught to these students in the context of their lifeworlds. Educators cannot assume that this skill will be developed unless it is consciously taught.

What follows are further descriptions of a culturally empowering classroom; an environment that develops “voice,” of students, the ideological self in the Bakhtinian sense. Such an environment enables students to use resources to accomplish individual and group goals. If these are lacking in some critical degree, in the classroom

environment where African American students predominate then old epistemologies and relations of dominance will persist. In a culturally empowering classroom the teacher is aware of structures at play that tend to limit the educational outcomes of students such as racism, local manifestations of globalized neoliberalism as Tobin (2009) has described it. Stakeholders will recognize the existence of authoritative ideologies that have been established by the limiting motives of racism, classism, and globalization. These ideologies will be present, consciously and unconsciously, in the attitudes of administrators, teachers, and peers and adopted by students themselves. In these culturally empowering learning spaces there will exist countering, liberating ideologies that come from students, teachers, and other stakeholders. These ideologies will compete for predominance in the minds of teachers and students at any given moment. The environment will have the physical, virtual, and mental resources available to the student to fashion empowering solutions to individual and collective problems.

In a culturally empowering classroom there are, ideally, consortiums of collaboration with other people who are involved with the same learning topics or who are otherwise stakeholders in the learning process. The classroom is not walled in but is extended in its reach from local through global contexts of education. Interactive technologies can provide this extension of the classroom. Interactive technologies facilitate synchronous and asynchronous cross-pollination. Technology tools, particularly those that foster online collaboration, will not only be deployed to elevate the efficiency and effectiveness of problem solving but will be directed to solving problems that are relevant to the lifeworld of African American students. Focus is given to curriculum design that mediates the tension between the push for standardized testing and the deep

need for African American students to develop skills that address problems specific to their local community's developmental needs.

Not only are technological resources made available to students to leverage, but also teachers provide students the ideologies that support the positive identity formation of students as agents capable of achieving goals relevant to their community. There is recognition that identity development is central to the education process. Identity formation of the individual student is tied inextricably to supporting the motives of the wider community.

Incubating in such culturally empowering environments, developing the mastery over resources available to them, becoming grounded in liberation ideologies that can disarm constraining ideologies, students will establish positive identities as agents for individual and collective uplift. Students will gain the facility to examine problems in relation to wider structures that currently tend to reinforce their subordination in and domination by society at large. With the development of the ideological self, a positive affective identity formation, students will gain the agency necessary to counter and transform limiting ideologies and structures both internal and external. As students are afforded opportunities to appropriate the resources in a culturally empowering learning environment, they will simultaneously develop identity constructs that will persist even in the face of more deeply constraining structures established on the meso and macro-levels. There is even a chance that this enhanced critical awareness will position them to participate in efforts to transform these meso and macro-level structures.

Cultural Historical Activity Theory – Framing the Unit of Analysis

The Cultural Historical Activity Theory (CHAT) also has promise in conceptualizing transformative, agentic educational practice that can further the educational goals of the African American and other minority collectives. The unit of analysis of this theory reaches beyond the individual personal activity and subjective reality in isolation from the context of the wider fields of social interaction. According to this cultural theory, individual activity, including learning in the classroom, is in symbiotic or dialectic relation with the wider community within which individual activity is embedded. According to Roth and Lee (2007, p. 189), "CHAT leads to changes in the location of representing what is educationally relevant: Its inherently dialectical unit of analysis allows for an embodied mind, itself an aspect of the material world, stretching across social and material environments" Hence, individual learning goals must be considered in context of the wider goals of the community within which the individual is situated. This is precisely the thrust of this study on urban educational practices. Interactive technologies are viewed as tools that enhance the agentic activity of individual | collective African American student achievement. They can facilitate knowledge construction in iterative and accumulating developments, not unlike the multiplier effect of money in a closed economic system, thereby magnifying the capital wealth (knowledge capital) of the entire community. This unit of analysis is a basis for this study.

Chapter 3

Using Interactive Technologies to Create a Multiplier Effect of Meaning Making in Math Classes

What can youth teach us about learning through their practices on friendship-driven on-line network spaces?

In 2006 the MacArthur Foundation sponsored a study to help determine how digital media are changing the way young people learn, play, socialize, and participate in civic life. The resulting white paper, published in 2008, is titled Living and Learning with New Media. In this study researchers identified three broad patterns of behavior practiced by youth during their use of on-line public networks. These behavior patterns are categorized in the study as hanging-out, messing around, and geeking out. They convey varying levels and intensities of cultural capital production and exchange. The findings of this study have much to teach educators about how to leverage student tendencies and competencies enacted in informal fields of activity in order to enhance learning in more formal, educational settings.

Hanging-out

Youth these days hang out with each other not only face-to-face but also on social networks. The social bonding that takes place when young people hang out outside of the school setting can cross over the school boundary and significantly affect the in-school cultural climate and hence the learning that takes place inside schools. The hanging out that youth do on online social networks is similar in many ways to how it is done face-to-face; however; there are many new educational benefits to on-line hanging out that adult

educators would be wise to recognize. Referring to on-line hanging out, the MacArthur white paper posits

> "while hanging out with their friends, youth develop and discuss their taste[s] in music, their knowledge of television and movies, and their expertise in gaming. They also engage in a variety of new media practices, such as looking around online or playing games, when they are together with friends." (p. 14)

Later I discuss, using the theoretical lens of James Gee (2007), some of what educators can learn from students playing with on-line games.

Messing Around

The Living and Learning with New Media white paper (2008) gave the following definition of the messing around on-line activity by youth:

> Unlike hanging out, in which the desire is to maintain social connections to friends, messing around represents the beginning of a more intense, media-centric form of engagement. When messing around, young people begin to take an interest in and focus on the workings and content of the technology and media themselves, tinkering, exploring, and extending their understanding. Some activities that we identify as messing around include looking around, searching for information online, and experimentation and play with gaming and digital media production. (p. 20)

There are several salient aspects of students' on-line messing around from a social cultural perspective that are important to leverage in public school teaching practices. One aspect is the messing around by youth in virtual spaces, which is a form of social production, or enactment, where learning and identity formation are continuously

happening at varying levels. Participants exchange information and ideas and give each other mutual support. They sanction each other when an activity does not coincide with the common interests that fundamentally bind the group. They positively reinforce each other when actions do support the group, thus strengthening group bonds. Participants in these spaces are consciously and unconsciously inscribed by the ideologies of others in the shared space. That is, they internalize and subsequently enact the values of others. Another important aspect of students' on-line messing around is that physical distance between participants is not necessarily an issue. Participants can still connect in on-line spaces and influence each other's learning and identity formation despite never having met in person.

With most on-line messing around, youth members are the main directors and authors of the cultural production that occurs. The activity is primarily self-directed, with adults on the periphery. Even though adults may have designed and continuously maintain elements of the shared space, the youth are in control of how resources are used within the given constraints, generating new cultural artifacts and new cultural inscriptions of each other. Time is not as great a factor either. Associates are able to access each other at practically anytime of day, synchronously or asynchronously. Dialogue is constrained only by their access to a networked electronic device.

Geeking out

Youth on-line geeking out has all of the aspects of hanging out and messing around but with higher intensity levels of activity that also entail more specialized knowledge and associated competencies. The white paper (2008) says of student on-line geeking out that

> [w]hen young people geek out, they are delving into areas of interest that exceed common knowledge; this generally involves seeking expert knowledge networks outside of given friendship-driven networks. Rather than simply messing around with local friends, geeking out involves developing an identity and pride as an expert and seeking fellow experts in far-flung networks. Interest-based groups, either local or online, or some hybrid of the two where fellow geeks will both produce and exchange knowledge on their subjects of interest usually supports geeking out. Rather than purely "consuming" knowledge produced by authoritative sources, geeking out engagement involves "I am the Greater God of video editing." (p. 33)

One salient aspect of youth on-line geeking out that is important to leverage in teaching practices is that youth usually demonstrate highly skilled competencies in producing the artifacts that signify the learning and enculturation that have taken place. With geeking out cultural enactment and learning that takes place can push the boundaries of existing knowledge, because the processes of knowledge creation are not completely bound by traditional rules, conventions, values of, and sanctions on what constitutes knowledge and valid forms of expression. Thomas Scheff (2004) says, with regards to negative sanctions, when considering social control – it seems helpful to consider the effect of induced shame, through negative sanctioning to produce conformity. This then speaks to the ability of individuals to come to their own conclusions of what is normal and what is abnormal or shameful. This ability is tied to Self Esteem. "Applying this idea to the group level, negative sanctioning initiated by established group members against less established members who transgress the rules of

the group, has a role to play towards helping the group to reach its goals. It can serve to fortify or support the group's disposition to withstand negative sanctioning or limiting structures of the larger society that the group is embedded in. These groups then can embrace their own forms of knowledge and competencies that are divergent from mainstream or dominant forms of knowledge. This is a basis for innovation. Confirming this point in its reference to on-line collaborative gaming spaces, the white paper (2008, p. 30) posits, "In all of these cases, players are engaging in a complex social organization that operates under different sets of hierarchies and politics than those that occupy them in the offline world."

With geeking out youth take pride in their self-authored products and unique competencies. They take pride in the recognition received by members of their group for producing specialized knowledge and artifacts. The positive reinforcement received is a motivator for continued and deeper incursions into the specialized field of knowledge and cultural production. Another important aspect of geeking out that is applicable to formal educational settings is that the competencies developed in this activity can often transfer into other fields that have resemblances to the spaces in which they were initially developed. Youth evidence higher-order learning by being able to transfer and apply their specialized knowledge and competencies to novel situations. Adults may be involved with the learning and production that occur, but they are not leading or directing it. Adult educators may find themselves in the reverse role of learning from a student who is leading the way. Through on-line hanging out and geeking out, youth demonstrate highly engaged modes of cultural enactment and learning that inextricably involve both their

identity and competency development. They demonstrate adaptability to using on-line networks for production and exchange of knowledge and media artifacts.

As a math teacher who uses technology in the curriculum, I consistently observe students demonstrating a readiness to transfer their developing on-line competencies to the classroom. Students continuously search for ways to express their evolving identities through their competencies in school and out. The fields of their private social life have porous boundaries that are always in interchange with their school life. Students bring their acquired self-directed competencies, experiences, and tendencies to the school table, whether this fact is recognized and leveraged by school educators or not. Teachers should ask what the on-line, self-directed activities of students could teach them about how to teach youth today. Teachers and other stakeholders can leverage the cultural and knowledge capital produced through student on-line activities to enhance and accelerate student learning. Teachers can evolve effective strategies of teaching that plug into this on-line habitus of students and leverage it to reach more formal educational goals. This means mobilizing similar resources that can be found in out-of-school online network spaces to produce similar products in school.

Interests and Positive Sanctions

Student on-line activity out of school is primarily self-directed towards self-interested goals. In my experience with students in public high school math courses, they often don't recognize how the study of math aligns with their self-interested goals. Teachers need to recognize the value of continuously negotiating with students the ways in which the skills taught in school can align with student interests, their developing ideologies and identities. Teachers must allow students freedom to explore, experiment, and exercise a degree of autonomy without

penalizing them for straying from predefined requirements or convention. Meaning making must be recognized as a joint and negotiated venture between students and teachers rather than as a one-way dictate from teachers. Furthermore, the products they produce should be validated so long as they relate in significant ways to the learning objectives at hand. Even when student-authored products don't seem to do so, they may express a serendipitous insight by the student that should also be validated. "Among fellow creators and community members, the context is one of peer-based reciprocity, where participants can gain status and reputation but do not hold evaluative authority over one another" (Living and Learning with New Media, 2008, p. 31). Students are thus motivated not just to get a grade from teachers but also to gain acceptance and positive reinforcement by both their peers and teachers, which can occur face-to-face or through an on-line activity.

Solidarity

Another important lesson to learn from student self-directed on-line activity is the importance of solidarity for youth who inhabit these spaces. Tobin and Roth (2006, p. 6) describes solidarity as "a term that denotes the fact or quality of being (perfectly) at one with someone else with respect to interests, sympathies, aspirations, understanding, and so on". Fostering collective social bonds should be recognized as essential in the context of formal student classes as well. Students in self-directed contexts are willing to show each other the ropes of the specialized field of activity. Teachers should foster this solidarity among students; this leads to the understanding that everything that happens in the course affects everyone and that collective goals can be reached more effectively if everyone supports each other. The learning experience then transcends the individual and extends out through a ripple effect to all members of the group and even to the wider

community. In Tobin's words, "the more we work together in solidarity, the more solidarity we produce, that is, the more our interests, sympathies, aspirations, understanding, and so on converge and come to be shared" (Tobin & Roth 2006, p. 6). In effect students learn citizenry through their specialized group contributions.

As a teacher of mathematics who is keen on integrating technology into the curriculum, I see high value in leveraging self-directed student sociocultural capital and competencies in the classroom to enhance my students' meaning-making potentials and fluency with mathematics. In doing so, I find that my students are prepared to meet me, as their teacher, more than half way towards accelerating their learning.

What the Computer Field Taught Me About Education

Herein lies a reflection on some of the things I have learned from my past academic and professional experiences I consciously, and sometimes unconsciously, attempt to parlay into transformative educational practices for my students on a daily basis.

Standards

My first job out of college was as a database administrator/programmer at Chemical Bank on Park Avenue in New York City. In that first employment experience I learned that field definitions were centrally defined and standardized. All of the programming developers depended on these standards to accomplish their individual work. My job was to make sure that this central repository of data definitions was maintained according to given naming conventions and standards for common access. Even the slightest error could affect many programmers and many new or existing

applications. Immediately, the notion of just doing my own piece of work was gone. My work was inextricably entwined with the work of others at every turn. When I teach my students, I want them to experience this interdependence with each other in the tasks and projects they do. I want to teach them that their problem solving may be for some immediate individual gain, such as passing a quiz; however, in the long term they should see their skill sets as resources and affordances for their wider groups and communities.

Groupware

In the mid- to late-1990s with the advent of the Internet, the methods of developing computer applications changed, and I was keenly aware of this change. There was a greater push towards collaborative application development, and the collection of computer software tools used to accomplish this was called groupware. The application development platforms I jumped on while I worked at J.P Morgan and later at Marsh and McLennan were Lotus Notes and Java. They were referred to as RAD - Rapid Application Development. This allowed users to access company resources and computer processes remotely through the company intranet and through the World Wide Web. I was truly fascinated by this type of technology, and I quickly became certified to do this work, which I did for the next ten years or so of my career. As the technology matured, these companies moved on to other platforms, but I did not keep up with them.

This kind of collaborative work fed beautifully into my vision on how African and Latino American communities needed to work collaboratively to solve collective problems. Later, as I moved into the field of education, I transferred that same vision to the way students needed to work to learn how to solve the collective problems of both the class and their communities. I pull from this same vision today when I assign my students

group projects that use Moodle (A content management system), Google Mail, WordPress.com (used for blogging), and powerful math modeling tools such as Maple. To become marketable in today's economy, all students in public schools must become adept at using Web 2.0 tools (A Web 2.0 site may allow users to interact and collaborate with each other in a social media dialogue as creators of user-generated content in a virtual community), with which they can not only access the world's information via the internet but learn how to manage that information, author their own contributions to existing knowledge stores, and multiply their collective knowledge of solutions to problems by leveraging interactive technologies. I advocate strongly for teachers to help students to learn how to use resources in a Web 2.0-enabled classroom to solve problems that are relevant to students and the communities from which they come. In schools where African Americans predominate, for example, this means that teachers must teach in culturally sensitive ways that will help African American students learn how to solve the deep problems facing their communities. This is not a separatist imperative designed to foster the continued divergence of Blacks from Whites. It is an attempt to level the playing field so that Blacks can compete and hold their own in an increasingly technologically demanding workforce.

Maintainability and Extensibility

One of the main lessons I learned as an application developer is that applications must be both maintainable and extensible. Maintainability in this context means that, once an application is rolled out, it should be documented and the code modularized well enough so that it is easy for someone else to isolate and solve a problem with the application quickly. Furthermore, any application should be extensible such that newer

functionality can be added easily without requiring much rewriting of the existing code or radically changing existing processes. Extensibility also means the possibility for expanding the capacity and scope of an existing application. In the financial industry applications must function across regions, time zones, and country codes. These concepts can be applied to teaching students from underprivileged communities by emphasizing they must learn underlying principles governing a field and be able to apply these principles in novel ways to address the unique problem sets of their communities. They must use the skills learned in math and science and extend them to the problem domain of their communities. Furthermore, they should see their contributions as adding to the collective knowledge capital of their communities so that it will be easier for the youth who are coming up behind them to maintain and extend further their current solutions into the future rather than to have to start from scratch. Solutions to problems faced specifically by African American and Latino communities and devised by the vanguard of these communities should be well-documented, maintained, and designed for extensibility. These students should be taught these approaches and attitudes, as I learned them in corporate America.

Obsolescence

One of the painful lessons I learned during my career as an application developer is that, due to the exponential growth of technology, the computer toolkit we had acquired became obsolete in increasingly shorter time periods. I had to retool constantly to keep up with these changes. At one point, for example, I was learning the Java platform because I was anticipating that the Lotus Notes platform was dying out. This constant need for retooling accelerated my desire to leave the field, as it was not my

intention or desire to keep up with all of these changes. Rather, I was becoming critically aware that it was time to use my foundational knowledge to assist with initiatives to help underserved communities value and leverage technology to reach their goals. Failure of these communities and the educational systems in them to help their youth come up to speed with the changes in technology would clearly result in these youth not being able to adjust to demands of a twenty-first-century economy. They would become obsolete themselves, enter the lower rungs of society, and likely remain there.

My main point with going into the above discussion is that exponential advances in technology are changing the way educators and the society at large has to address the ongoing issue of racism and its various manifestations of oppression. We have to recognize that these changes are speeding up the movement towards a condition where African Americans and Latinos especially, will not collectively develop the necessary survival tools to avoid becoming a permanent underclass in society. As one who has become intimately involved in the forces of change due to technology in both the corporate world and the education world, I could not and would not in good conscience fail to involve myself in researching how to advance the specific educational needs of African American and Latino students who might otherwise be pushed to the extreme abyss of technical incompetence.

Collaborative or interactive technologies foster the acceleration of the cultural and social capital exchanges in the Bourdieusian sense, needed to accomplish the progressive development of African American communities. Collaborative technologies can facilitate a multiplier effect on knowledge capital that can reverse the knowledge and achievement gaps faced by African American and Latino students. An increase in the number of

people distributing information (capital) in a closed networked system will increase the frequency that each person receives various forms of capital in the Bourdieusian sense. This increase will have a multiplier effect of knowledge capital. That is, the net gain in the knowledge capital which each person in the system realizes is increased many more times than if a person acts alone or interacts with only a very few other people. The goal, then, in urban schools is to utilize tools, processes, and approaches that will increase the frequency with which individual students in a networked system (i.e., an extended classroom) can share information with other stakeholders. In this paradigm students appropriate interactive technology tools that facilitate timely sharing of information. The more knowledge capital that circulates in the system, the better will be the overall depth and quality of meaning making, learning, and problem solving. Whatever promotes effective, meaningful discourse around problem scenarios, which engage students, also promotes an increase in the meaning potential for finding effective solutions for those problems.

Modeling and Feedback in Collaborative Learning Spaces

The National Research Council (NRC) report, How People Learn (2007), also offered critical insights into how the use of technology, backed by sound pedagogical principles, can enhance the learning of underprivileged students and help close the knowledge and achievement gaps they face. One method it discusses is using technology as a modeling tool. In my experience, modeling problems visually through technology has tremendous advantages for students with math weaknesses. There is a strong trend in modern societies of visually modeling or simulating a problem set using advanced technologies such as CAD (Computer Aided Design). It is popular in current gaming

design and many fields such as medicine, meteorology, architecture, film, and aviation to name just a few. There is no reason why this approach should not aid those students who struggle with the complexities in math and science in the classroom.

Using technology to aid learning has another advantage. It gives students and teachers more opportunities for feedback. Society today takes for granted the power of writing a paper electronically and submitting a draft for review to peers and a teacher who are in some cases a half a world away. The reviewer can offer a critique by marking up the document electronically alongside the text without changing the original. The author can then accept, reject, or query some or all of the changes. The student can explore what the results would be (i.e., see how the text reads), if various changes were accepted. This same process applies equally well to math and science models. Students can construct a model of a problem along with a possible solution set and submit it for review. A teacher can then mark up the model or point out to the student areas where the model may be enhanced for a better solution. Students can then explore the suggested solution path. This aspect of scaffolding is critical for students who are weaker in a given semiotic domain and who are struggling to navigate it. It also enables students to become more reflective and aware of successful strategies in navigating the semiotic domain. As How People Learn (2007, p. 205) noted, "technology creates opportunities to incorporate into curricula a meta-cognitive approach to instruction by using an inquiry cycle that helps students see where they are in the inquiry process". The end result is that students learn the processes of becoming adept in a particular semiotic domain. They develop self-efficacy as authors/designers who not only function adequately in the semiotic domain but also advance that domain to wider frontiers through unique authoring/designing

contributions. The sound pedagogical use of technology by teachers affords promising opportunities in typical urban schools to mediate the academic weaknesses in math and science that African American students in urban schools tend to have.

Collaboratories - Virtual Learning Spaces

The How People Learn report (2007) advanced one other concept extended in this study to address the learning needs of students in public urban schools: Current technologies can provide opportunities for these students to collaborate with peers, teachers, experts, and anyone associated with a particular semiotic domain of interest via virtual learning spaces, or what the report refers to as *collaboratories*. In my experience many minority students already have aptitude for using collaborative technologies such as those involved with their use of cell-phones and their social media interactions, as with Twitter and Facebook. Unfortunately, this collaboration tends to focus not on academic and collective socio-eco-political problems but rather only on non-academic, social circle concerns. Educators would do well to leverage the familiarity of underprivileged students with the social media usage of technology and apply it to academics to address knowledge and achievement gaps.

The achievement and knowledge gaps faced by African American and Latino students in math and science have deep, historical, and macro causes. The digital and knowledge divides are macro national problems requiring macro national solutions. The beauty of the Internet and collaborative technologies with respect to these problems is that they are designed to solve problems that are distributed over dispersed geographical domains as easily as problems that are locally situated. Furthermore, the technology can be used to roll up or incorporate solutions of local problems into models that treat the

same problem from a macro or global perspective. The How People Learn report used the example of students collecting and analyzing local data related to global warming and then uploading their local findings to a centralized global model of the phenomenon for shared use through collaborative technologies. In the same way, students from underprivileged communities can roll up their solutions to local problems into models that treat the same problem from a macro or global perspective through the vehicle of collaborative learning spaces.

Specific Affordances of Interactive Technologies

Interactive technologies in education offer powerful tools for addressing field-trip and meeting constraints and granting access to experts in a given discipline with video-based problems, computer simulations, and electronic communications systems that connect classrooms with communities of practitioners and experts in science, mathematics, and other fields. All of this allows students to collaborate in wider collaborative learning communities. In these spaces students can use shared collaborative and visual tools and see how their local data fit into a larger model (e.g., local environmental studies of climate issues). Integrating this approach into the curriculum results in positive student attitudes towards and engagement with complex problems.

Students can be engaged in online learning communities for creating, sharing, and mastering knowledge: exchanging real-time data, deliberating alternative interpretations of that information, using collaborative tools to discuss the meaning of findings, and collectively evolving new conceptual frameworks. Knowledge and meaning are obtained through the synthesis of multiple dialogues and points of view, where each utterance (in the Bakhtinian sense) is predicated on those that came before. In an interactive virtual

learning space, these utterances can be contributions to a threaded discussion on a discussion board. To accomplish this I have, for example, used the Moodle collaborative software as a tool in my high school math classes. The outcomes of this collaboration do not benefit only the individual student; they can become a repository of relevant knowledge capital by and for the community at large. These outcomes become a collective competency, directed at meaning making that is meaningful to both the individual and the community the individual comes from. It will remain a collective competence so long as what the discourses and knowledge produced remains directly relevant or attuned to the common problems faced by the collective. Once this rule is violated, then the environment has been compromised. An accumulation of compromises past a critical point will render the collaborative environment ineffectual to uplift either the individual or the collective. This possibility has to be vigilantly managed by both the participants in and the designers of the learning space.

Scaffolding and Modeling with Web-Based Tools

One vital step forward in providing urban math students with the tools that they need to accelerate the meaning-making potential within the domain of high school math classes has been the availability of on-line math programs that can more clearly reveal math relationships and solutions through powerful graphical user interfaces. There is a plethora of accessible web-based tools that can help enhance learning for students in urban schools. The best of these tools allow students to generate visual models of math concepts that they learn in their courses. These models allow students to inspect critical aspects of the problem they are modeling without getting bogged down in the mechanics of revealing those critical aspects. The best of these modeling tools allow students to

interact dynamically with the model, changing parameters and presentations as desired, in order to further expose the nuances of a problem. These better tools enable students to share their models with others to get feedback, and they are able to update the model based on this feedback and publish their findings.

There is another dynamic feature that I think makes for a better on-line tool, the ability of students to couch their mathematics within the context of a real-world example. Such a tool allows a student to define a real-life problem. It makes available constructs that facilitate establishing the parameters of the problem. These constructs are applicable to math tasks, formulas, figures and shapes, typical formulas, and preexisting models of a similar kind. Students in essence are able to construct full-blown virtual representations of their scenario that are realistic and map well to the real-life problem.

In their research paper, "Interactive Tools for Learning Mathematics: Best Practices," Barry Cherkas and Rachael Welder (2012, p. 275) of Hunter College identified three major types of on-line interactive tools to enhance math learning using web-based tools: (a) static, "meaning that knowledge-seekers read passive content published on a website similar to material printed in a textbook; (b) interactive, "having the ability to provide the learner with a richer experience … but they [the tools] do not actually teach students how to solve problems;" and (c) dynamic, meaning "that knowledge-seekers interact with web tools that generate fresh customized content based on user input." In other words, the dynamic tools are interactive and responsive to user-defined parameters. It is, of course, the last type of on-line tool that affords greater learning potential for students. As Cherkas and Welder (2012, p. 276), stated "the value of such resources resides in their ability to give learners the opportunity to develop

visualization skills, explore mathematical concepts in innovative ways, and obtain solutions to self-selected problems … giving learners "more control of their learning environment to meet their individual cognitive and developmental needs." Part of the best practices of using on-line math tools, as identified by Cherkas and Welder (2012, p. 277), is the use of tools that can provide "insight into the development of reasoning behind the mathematical ideas discussed." So the tools do not only present solutions; they can aid in exposing the reasons and concepts that support the solutions. The tool helps with first principles of the concept that the student is exploring and using to solve problems. These advantages which facilitate higher ordered thinking are precisely what students in urban public schools need in order to accelerate their learning and close achievement gaps between them and their non-urban and private school peers.

Using ethnicity data they collected over five websites dedicated to math education, Baranchik and Cherkas (2002) were able to show that ethnic minority students use these sites more than Caucasian students. The authors suggest that students who have traditionally had difficulty handling higher-level courses and/or were not getting the help they needed in schools, found high utility in on-line tools to help gain a better understanding of the concepts. I have made use of one such on-line math tool created by Cherkas and located at webgraphing.com. This tool allowed my Algebra 2, Pre-calculus, and Calculus students to graph higher-ordered functions and to investigate their properties with relative ease. My students appreciated the ease with which they were able to find critical aspects of functions quickly and to use this information to answer higher-ordered questions about concepts that they were studying in class. I think this kind of on-line tool use will become more common in classes such as mine. I believe, though, that in

the future these tools will gain in their dynamic capabilities as I described above, allowing students to construct full-blown virtual models of real-life problems with relative ease and share them, thus affording greater opportunities for making their knowledge construction align more closely with what is relevant to them and their affinity groups.

I am currently exploring a math tool called Maple (a powerful math modeling program) that does this kind of modeling and combines mathematical modeling seamlessly with student co-authored rich text. The Maple work environment is standalone; however, the worksheets produced can easily be shared through a network. The worksheets can be exported into html format so that recipients of these worksheets can view them. I can envision a time when math worksheets will be editable by tools other than Maple; just as MS Word and Excel files can be modified by other applications. These word processing programs allow knowledge construction and sharing. I see Maple doing the same but aiding in the construction of math knowledge as well as fostering dialogue and fluency with mathematics. This particular tool has math capabilities ranging from Arithmetic through Advanced Calculus and beyond. As such, it can be intimidating for students, if the teacher is not careful to help students manage these program capabilities. For instance, Maple has both in-line and menu-driven modes for accomplishing almost every task. I have students work exclusively with the menu-driven options that are context sensitive; this makes powerful operations available with a simple click on a math expression, equation, or graph.

Criteria for Implementing an Interactive Learning Environment

Mindful of what was said about practices youth enact within friendship-driven on-line network spaces, there are essential practices necessary to structure an online collaborative learning environment in the school context, that leverage students' existing out of school technology activity, and that will tend to accelerate learning and achievement of student goals in urban schools. In such an environment it would be easy for both teachers and students to create or modify any pre-existing content knowledge. The products produced by students engaged with interactive technologies would be not only easily catalogued, but also easily shared, with students having some control of what can be shared and when. This gives them a sense of authorship of their work. The interactive environment would allow for synchronous, real time communication between students, and also between stakeholders who are not immediately present, thus expanding the boundaries of the classroom that could conceivably include students and educators situated across the world. Of course the learning environment would allow for asynchronous exchanges that would mitigate time and distance constraints between collaborators. There are other infrastructure issues to manage such as the capacity to handle a wide array of multimedia objects, scalability to Web 2.0 tools, and who will maintain and grow the infrastructure over time.

A researcher or educational consultant working to infuse interactive technologies into a curriculum at a given school should minimally assess these areas as for example: Non-existent, Recently Implemented, Low, Medium, and High. It would be important to give an urban public school periodic feedback on how well it is doing with regard to its implementation of a collaborative learning environment across the curriculum. The

promise of such feedback and subsequent advice will be a selling point to encourage a given school to participate in this project initiative.

Assessing for a Web 2.0 Learning Environment

Web 2.0 tools – online platforms that allow nonprogrammers to contribute content to the World Wide Web (O'Reilly, 2005) – are increasingly transforming society and also promise to have significant transformative effects on education in the foreseeable future. However, not all teachers are prepared to use Web 2.0 tools in their classes for the greatest positive effect. It is safe to say that most education practitioners are aware of the gulf between access to computers in the classrooms and the facility of both teachers and students to use them in ways to enhance learning effectively. Even when teachers make use of interactive technologies, there are gradients of how they use them ranging from teacher-centered and individualistic, to student centered and collaborative. It is the last usage that maximizes the meaning making potential developed by and for students and results in a higher level of math learning.

Justin Reich and his collaborators of the article entitled "The State of Wiki Use in the U.S. K-12" (2012) identified four general types of wiki usage by high schools across the U.S. The focus of this study was on wikis because of their collaborative characteristics. They are emblematic of Web 2.0 technologies, and they are easily accessible to schools that have a networked environment. The authors' primary research dataset came from a web site that offers free wiki usage to educators and students. The study identified four major categories of wiki usage along with their frequency of usage: (a) trial wikis and teacher resource-sharing sites (40%), (b) teacher content-delivery sites (34%), (c) individual student assignments and portfolios (25%), and (d) collaborative student presentations and workspaces (1%). The study found that wikis created in schools

that serve low-income students have fewer opportunities for twenty-first century skill development and shorter lifetimes than wikis from schools serving affluent students.

As a part of this study, the researchers developed the Wiki Quality Instrument (WQI) as a measuring rubric to ascertain the levels to which schools are using wikis to promote the development of twenty-first century skill sets for students. The tool has five major categories for assessment, each having several sub-categories. The five major categories with their number of sub-categories are (a) Information Consumption (2 items), (b) Student Participation (4 items), (c) Expert Thinking (5 items), (d) New Media Literacy (6 items), and (e) Complex Communication (7 items). Coders of wiki changes made in a content management system such as Moodle or Blackboard assess whether students participate in activities that support the development of twenty-first-century skills as part of their high school curriculum. Their findings, after the application of this rubric to a sample of 241 schools, indicate that schools serving more affluent students provide more opportunities for development of twenty-first-century skills, as measured through wiki usage. Furthermore, when teachers do use technology in the classroom, it is more for the purpose of gaining efficiencies with existing practices (such as disseminating teacher-generated information) than for the purpose of transforming those existing practices (such as allowing students to author and share newly-created knowledge). It is precisely these collaborative kinds of activity, i.e., leveraging Web 2.0 technologies that will afford urban students the means to accelerate their learning exponentially and prepare them to thrive in modern economies. I believe the research I've conducted in my classes has shown the beginnings of this progress with my students

Chapter 4

Methods of the Methodologies

Study in My High School Math Classes

The site that I have chosen to research is my own classroom where I currently teach high school mathematics. I've taught high school mathematics in New Jersey public schools for the past 7 years. I've taught at the site of current research for the past 2 years. The school demographics at my site are 55% Latino, 40% Black, 5% Asian or other, about 650 total students. There is a strong focus on academic achievement at the school. The school was recently removed from the NCLB "school in need of improvement list." Ninety-eight percent of my 100 juniors passed the HSPA over the course of two years. The principal is African American with a mathematics teaching background. Seven out of ten administrators in the school district of four schools also have a mathematics background. I teach mostly juniors and seniors. The courses include, Algebra 2, Pre-Calculus, AP Calculus, and College Algebra. The current year is my first time teaching AP calculus, though I've taught non-AP Calculus in the past.

During the course of the 2011-2012 school year I engaged students in projects and other activities that I hoped would develop their identification of themselves as doers of mathematics not just for their own benefit but also for the greater good of their communities. This is in keeping with the unit of analysis of my research. I did not focus on student learning activities in isolation even if those activities involved advanced technologies, rather, I focused on activities of groups of students in collaboration through interactive technologies for the purpose of increasing their group agency and their

capacities to address socioeconomic issues in their communities. This goal was reflected in the student project requirements in one way or another, as I attempted to develop this collective identity of my high school math students. The following are some activities involving interactive technologies in which I engaged my class to do this. I've provided student access to resources on the Moodle placed there either by other teachers, other students, or myself. Students were allowed to copy and then modify contents. Resources included PowerPoint slides on math lessons, videos on particular skills, assessments, and journal entries in forums. I created folders in Gmail where students could share electronic files with each other and me. I created Web sites for students in Google to establish virtual math identity and share files with the public (i.e., the rest of the school). I made use of a smart board to facilitate whole class sharing of products. It is easy to take this interactive technology for granted, until such time that in becomes inoperable. Then its high utility for facilitating whole class discussions becomes even more apparent. I provided student access to Google survey, Word Press, and computer math programs such as Geometer's sketchpad and Maple. Co-teaching (student to teacher and student to student dialogue), was a principle teaching practice employed in my classes that allowed students to share their perspectives on math. Maple was used frequently (a computer math modeling application). It allowed students to create narratives or problem scenarios, and seamlessly embed math into them, and then share this with others by exporting it as an html file.

Discourse Analysis Within a Cultural Context

Throughout the 2012 school year, I collected data in order to ascertain whether or not students were developing strong identities as doers of mathematics and problem

solvers on the behalf of their communities. What follows are descriptions of the types of student-produced data I've gathered that potentially show this identity development. One such data source that I captured in Moodle is written statements by students on the selection of an issue they chose to address. I paid close attention to the students' stated reason for why the community issue was selected in order to ascertain levels of student identification with the issue.

Another student data source that potentially show student development of strong identities as doers of mathematics is the student insider language, for example, terms such as *my problem* or *my community* may indicate this identification. I also collected student self-placed captions surrounding the content of PowerPoint slides of a student problem presentation. These captions add meaning to the presentation and often reveal student valuations of the selected issue. These captions can also represent part of the student insider language. Looking at the pictures a given student selected to surround the information in the slides, one can surmise that the student has formed a definite ideological opinion about the community problem he/she chose to work on. Further evidence of this is when a student endorses active involvement by sympathetic listeners to help with the student-selected problem.

Another student data source I focus on is the spontaneous dialogue in which students engaged while presenting their projects to the whole class. These data sources were recorded in my field notes and I categorize them as insider language.

Students transcribed into Moodle forums interviews of community members. During presentations students seemed very interested in expressing the opinions of their community members about the problem they presented. At this point I can only speculate

why this may have been so. I will venture to say students may have felt that these interviews added an authentic voice to the problem, which infused a greater relevancy of the problem to the student.

Students' written modifications of existing word problems were captured in a Moodle course. When I asked students to modify an existing problem in some significant ways, I had in mind to determine if their modifications reflected in any way an attempt to address problems, which they saw in their communities. If this were the case, then this would also be evidence of a growing identification with community problems. I've also captured in Moodle, answers to the journaling questions I asked of students throughout the course. I've recorded in field notes statements by students indicating their eagerness to showcase their work to the whole school using bulletin boards outside the classroom.

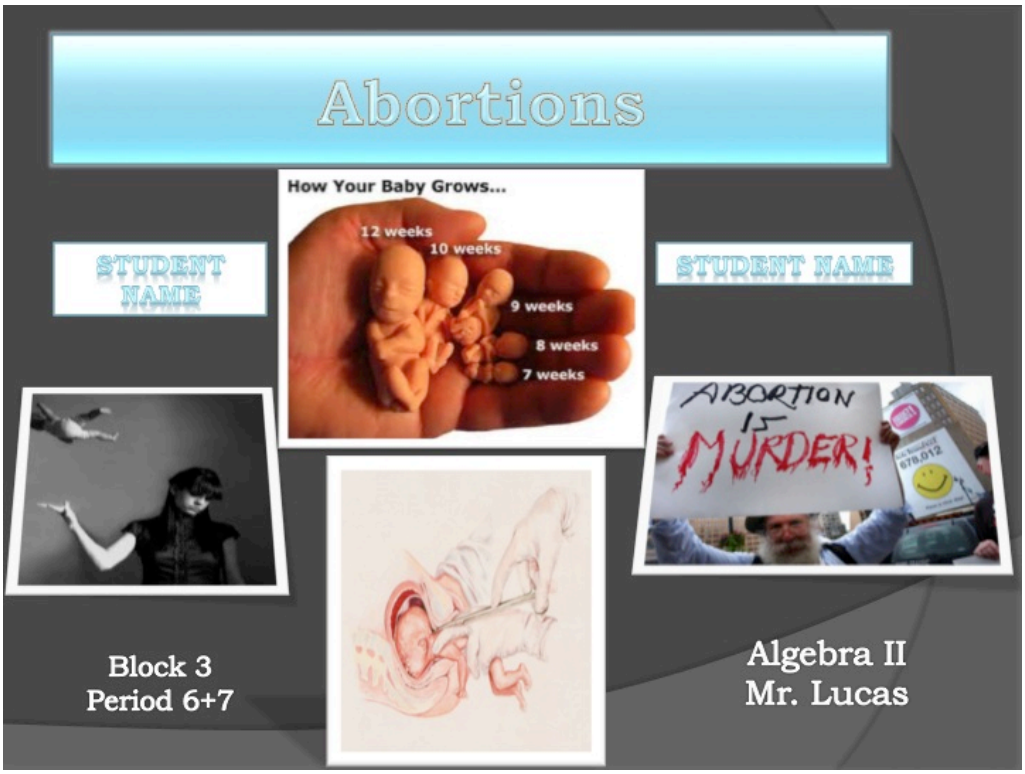
Another data source for the evidence of student identity development was the portfolios that students were asked to complete for the third marking period. While working on the portfolio, I asked students to comment on the work that they did and their level of acquired understanding. I think that this product can be revealing of how students valued the project work that we did in comparison to the other types of math work and whether they found it more relevant to their developing competencies as problem solvers on the behalf of their communities.

Later I interpret in detail some student produced data using particular coding tools. What follows are examples of how I interpreted some of the above data sources in more general terms.

An example of the data evidence described by student-added captions is shown in figure 1, a PowerPoint slide on the community problem of abortion. The added captions

evidence the formation of a definite ideological opinion. Generally, I think that the added captions to PowerPoint presentations on community issues done by most students gave evidence of the students' developing ideological identities as agents for their communities.

Figure 4.1
Abortions



A highlight of the student portfolios is an excerpt from the portfolio introduction done by a Pre-Calculus student:

> However, after the HSPA we moved onto better things like matrices. Not only did we learn how to plug matrices into a calculator, we learned how to create our own problems in Excel. We also learned about synthetic and long division with polynomials. It was very fun. Now we are working on a group project dealing

> with any community problem of our choice. We have to model the problem with "dummy data" and then get real data that shows the function of our problem.

One can surmise from this statement that this student gave a positive valuation ("we moved onto better things"*)* of the group project dealing with a community problem.

An example of journaling questions as data evidence, is demonstrated by one student who answered the question about his experience with doing a project related to his community thusly:

> I think this project was good in helping us recognize some of the problems existing in our community but it wasn't really enforceful [sic], I don't think it had a very powerful effect on me. I felt that this project was just a brush up on my presentation skills, but yea it was an ok experience.

This comment indicated to me that the goal of helping the student become aware of the relationship between math and the potential to use it to address community problems was achieved. He was looking for a more "powerful effect." Though at first glance this may seem to be a negative evaluation, it could also indicate that this student is ready to go beyond the awareness phase to a phase where he is actually making a difference with his research. He used the term "*enforceful,"* which could be read as the developed competency to make a difference in the problem area.

Another student wrote the following in response to the journaling question, "What is a problem solver?"

> A problem solver is someone or something that solves problems by making it easier or coming up with more than one solution. In math, a problem solver can be a calculator or a formula that helps solve an equation. In life a problem solver is someone who helps others with their issues, for example, a therapist or a complete stranger can be a problem solver.

I took particular note of her saying "In life a problem solver is someone who helps others with their issues." This is an indication that the student understands that problem solving has importance in relations to others, which for me indicates a development of collective identity formation.

Coding Tools

The Coding I do for positive evaluations of student discourse as they work towards collective and individual goals takes place over all the types of products that were collected while students engaged with math content using technology tools such as the ones I mentioned. The following is a tool for discourse analysis on student dialogue and authored products that I adopted and adapted from Lisbeth Amhag and Anders Jakobsson (2008), who used it in their analysis of student dialogue while the students were taking an online course. This tool is in keeping with Bakhtin's ideas of ideological becoming.

Table 4.1
Dialogic Levels of Discourse

Research Rating from low to high	Dialogic Level	The levels of thematic patterns in the dialogue
C	**Passive and authoritative**	• Accepting and confirming • Passively reproducing knowledge • Monological and authoritative • Failure to explicate the possible meaning potential (in the dialogue and through artifacts) as a basis for learning, development and solving collective problems **Meaning potential can be understood as a sample space that is composed of all the possible ways to understand or interpret statements made in a dialogue.**
B	**Persuasive and preliminary negotiation**	• Accepting, confirming, and questioning • Elements of passively reproducing knowledge • Negotiations • Responses and artifacts create possible meaning potentials • Failure to use meaning potential as a basis for learning, development and solving collective problems
A	**Persuasive and co-authorial negotiation**	• Accepting, confirming or actively questioning and a desire to develop the discussion • Few or no elements of passively reproduced knowledge or artifacts • Others' statements reworded into own words • Participants are shareholders and co-authors in the account, negotiations • Responses create possible meaning potentials • Use of meaning making actively as basis for learning, development of and solutions to collective problems

The below table summarizes my research questions and sources of data.

Table 4.2
Research Questions and Data

What questions are most central to my study?	**How are these questions related?**	**What kind of data will answer these questions?**	**How will I collect this data?**	**My rationale for my choices**
How, if at all, do student discourses and authored products, express development of those students' ideological self, privileging their own "voices," i.e., their own ideas of what learning activities will benefit themselves? **Rating is lowest, 1**	This first question is meant to ascertain if students feel free to counter ideologies and structures that impinge on their agency in education.	•Synchronous and Asynchronous dialogue •Student journaling and other posts to Moodle •Maple worksheets that combine text with math •Project presentations	•Interrogation of available asynchronous discussions – some captured in Moodle forums •Saved Maple worksheets and other electronic files shared in Gmail folders.	Students' achievements must be assessed in relation to their developing identity, critical sense, knowledge construction towards self-relevant problems, and developing agency to achieve individual and community goals.

Table 4.2 Continued Research Questions and Data				
How, if at all, do students' discourses and authored products express development of those students' identities as proactive actors in their field of activity (doing mathematics)? **Rating is 2**	The second question builds on the first and tracks the students' agency to proactively appropriate resources as needed to accomplish their individual goals.	Authored products over time demonstrating application of concepts learned towards problems relevant to self and identity group, as in: •Student journaling and other posts to Moodle •Project presentation •Project topic selections •Maple worksheets that combine text with math	•Observational data, exploration of interpretations and multiple meanings •Saved Maple worksheets and other electronic files shared in Gmail folders. •Posts of responses and artifacts to Moodle.	Opportunities to use Activity Theory in understanding the process of meaning-making, and developing agency to gather resources (interactive technologies) that will advance individual and group goals.
How, if at all, do students' discourses and authored products express that those students identify their problem-solving activities and goals as advancing the motives of their identity group and larger community? **Rating is highest, 3**	The last question examines whether students associate their individual agency with the goals of their wider group (African Americans doing math community)	Authored products that result from student participation in the following: •Projects •Extended school activities such as community service co-op courses, mentorship programs •All manner of social activism	•Observational data, exploration of interpretations and multiple meanings • Posts of responses and artifacts to Moodle • Shadowing while students are participating in activist social activities	Opportunities to use Cultural Theories (e.g., Historical Cultural Activity Theory) in understanding the process of meaning-making and developing agency of students to gather resources (interactive technologies) that will advance individual and identity group goals

I'm in my seventh year of teaching mathematics and using interactive technologies to enhance student learning. I have seen indications of my students developing an ideological stance and identity as problem solvers on behalf of student communities. Using the above dialogical tool during analysis of student dialogue will be helpful going forward to determine the level of student Ideological Becoming in the Bakhtinian sense. Another means to ascertain that students in urban classrooms are developing positive identity as doers of math on behalf of their communities is to gauge the level of synchrony, entrainment and solidarity amongst students and teachers in the classroom in the sense given by Randall Collins (2004, p. 48): "As persons the person becomes more tightly focused on their common activity, more aware of what each other is doing, and feeling, and more aware of each other's awareness, they experience their shared emotion intensely, as it comes to dominate their awareness." I hope to engender in my students this kind solidarity on a sustained and continuous level, while they work towards achieving common goals of the class and of their wider communities.

The research I do deals with macro level data, or data that can be captured and analyzed without the need to slow down student activity, as in slowing down video clips, for the purpose of observing behaviors that would otherwise be missed. Certainly micro level data, as in videotaping of students could prove to be very useful to understanding what is happening as students engage in mathematics while using interactive technologies. Micro data analysis can reveal levels of entrainment, prosody, and attunement, which can support claims of strong group solidarity. Tobin has done extensive work in this type of microanalysis of students within science classrooms and

has demonstrated its usefulness for revealing levels of solidarity or the lack thereof (Roth & Tobin, 2010):

> We show that specific prosodic features in face-to-face encounters—alignment and misalignment—are associated with the production of solidarity and conflict, which in turn are associated with successful and unsuccessful lessons. They are also associated with different degrees of solidarity and emotional energy that participants in science classrooms experienced. (p. 3)

Micro level data, as in video taping of students as they are engaged in the type of collaborative project work that involves community, can be coded for prosody, entrainment or sustained focus, and synchrony. This data can be compared to the same type of micro level data of students engaged in typical teacher centered lessons. Though I have not attempted this micro level analysis and comparison with my students, I have anecdotally noticed higher levels of student engagement, entrainment, and synchrony when students were allowed to author their own math products and were free to present them in the role of class teacher.

I would not want to overstate what this micro level analysis alone can reveal on its own in terms of identity formation in a given cultural context. Looking at micro level data in isolation from wider cultural structures in which students are embedded can lead to misinterpretation of events. For instance, simple smiles by students in and of themselves can be interpreted as positive emotional engagement but can actually be expressions of subversion or carnival (in the Bakhtinian sense) of a teacher's practice. However, this is true for all of the forms of evidence that I have listed thus far. It is only when one form of evidence is held together with all of the other student-produced cultural

artifacts that it is possible to achieve higher confidence levels that this collaborative, student-centered approach cultivates in students positive identity formations as doers of math on the behalf of their communities. Having stated this caution, I find that my experience suggests that the levels of solidarity are markedly higher when students are given freedom to work on problems that are relevant to their communities and allowed to present them to their classmates and other stakeholders without undue teacher interventions. This may also translate into higher levels of student achievement in math. The positive reinforcements in classes can accumulate to the point where students will engender a propensity to enter into careers that depend heavily on mathematics.

Where does this approach lead? It can lead to a feedback loop of cultural capital forming and educational praxis that supports more than just individual positive affective identity formation. It can lead to positive collective group identity formation that can be the basis for transforming dominant structures that to this day have thwarted the educational aspirations of African American students. I refer to Jonathan Turner (2007) for aid in conceptualizing prospects for transformative agentic action, as the outcome of positive affective identity formation of participants in my project:

> …the flow of positive sanctions in an encounter tends to circulate among the participants to the encounter, with individuals mutually sanctioning each other in ways that build up local solidarities, although at times this flow of mutual positive sanctioning can work its way up to meso-structures and macrostructures. (p. 89)

This reminds me again of the multiplier effect of repeatedly circulating money in a closed system as a means of accruing wealth at an exponentially increasing rate. This, then, provides a cultural capital accumulation that may reach a critical mass, allowing for

transformational structures in the educational arena. The goal of this research is no less than such a transformation of meso-structures and macrostructures that tend to constrain the educational and life possibilities of African American students.

Data Collection and Analysis

The following is my interpretive analysis of student responses to questions asked at the beginning and middle of the school year to gauge the levels of students' affective attitudes towards doing mathematics. At first I assigned evaluations to student responses that indicate how, if at all, these responses addressed the essential questions I asked in this research. I repeat those questions here.

1. Do student discourses and authored products, express development of their ideological self, privileging their own voices, meaning their own ideas of which sort of learning activities will benefit themselves and their community?
2. Do students' discourses and authored products express development of their identities as proactive actors in their field of activity (doing mathematics)?
3. How, if at all, do students' discourses and authored products express that the students identify their problem-solving activities and goals as advancing the motives of their identity group and larger community?

I've made additional evaluative interpretations of the student responses. My focus was on my junior level Algebra 2 and Pre-Calculus classes. I placed my questions into a taxonomy that expresses the levels to which students identify their individual advancement in math with the motives of their identity groups in class, and beyond that, in their wider communities as they define them. If the given student response affirmatively addressed my first question I assigned the response rank 1. If the given

student response affirmatively addressed my second question, I assigned it rank 2. If the response affirmatively addressed my third question, I assigned it rank 3. Where students did not show evidence of a development of their ideological self, privileging their own voices at all, I assigned their responses rank 0.

The Amhag and Jakobsson's Levels of Thematic Patterns in dialogue was a tool I adapted to analyze discourse represented by student-produced products while engaged with interactive technologies. Student discourse was rated using this tool on a dialogic level scale of C to A, where C represents the least developed passive authoritative voice in the Bakhtinian sense, B represents the developing persuasive preliminary negotiation voice, and A represents the most developed persuasive and co-authorial negotiation voice.

Below are 15 questions asked of my junior level students at the end of the Algebra 2 course. It would have been preferable to ask no more than ten questions; however, most of my students were accommodating and offered responses to all 15 questions. See the appendix for the spreadsheet, Student Exit Survey, for the detailed analysis of student responses. The questions asked are duplicated here.

1. Please describe how your attitude towards math has developed during this course.
2. Please describe an experience with math during the course that helps explain your current attitude towards math.
3. When you were asked to create a math project related to your community, whom did you see as your community members? Describe them.
4. What is the usefulness of doing math projects related to community?

5. How can proficiency in math help you, if at all, to manage the career you are interested in?
6. Describe your experience with co-teaching.
7. Do you think co-teaching is helpful for students?
8. Describe some important characteristics of a problem solver.
9. Describe any connection you see with math problem solving and your community.
10. Describe the usefulness of using a graphing technology tool in math classes.
11. Describe the usefulness of using interactive technology tools like webgraphing.com site, Moodle, and Google Docs in math classes.
12. Describe the usefulness of using Maple with your math course.
13. Describe your comfort level with using Maple.
14. Describe how this course may have been different from how you learned math in the past.
15. Describe how you think the teacher could have improved the course.

Summary of Survey Results

Below is one example out of a total of twenty-two, of how I interpreted and ranked the responses to my fifteen survey question for one student. See the addendum for all student responses to my survey questions.

Table 4.3
General Student Survey

Questions	**Student Response**	**Analysis**
Please describe how your attitude towards math has developed during this course.	my junior year of math was really successful. They way i felt about math as truly changed this year. The way my teacher opened the year up, it maid me feel more comfortable about math. Throughout the whole year I had this certain excitement about math that never changed.	**Rank B - 2** This response indicates a continued growth of personal proficiency in mathematics.
Please describe an experience with math during the course that helps explain your current attitude towards math.	my biggest experience with math is the connection i had with my classmates. When I had to go to the board even when I didn't understand something my classmates helped me through it. That experience made me grow the attitude that I don't have to know everything. It's the effort that counts!	**Rank A-3** This statement indicates a strong collective identification of the student with the classroom, which indicates a positive identification. It also indicates the student's willingness to work at understanding in a proactive rather than passive way, even if it requires some help along the way from peers. Peer to peer learning can be more proactive than teacher to student learning.

Table 4.3 Continued General Student Survey		
When you were asked to create a math project related to your community, whom did you see as your community members? Describe them.	My community members were my neighbors. They people i see everyday when I'm leaving out to go to school or returning home from school. My community is made up of people who care for one another. The people in my community are the ones who stand up and protect where we live. The people in my community are the ones who help the elderly out when they are struggling. When someone new moves in our community we help the move in. Things like that show how well built of a community we are.	**Rank A - 3** Here the student shows a strong identification with her community group.
What is the usefulness of doing math projects related to community?	The usefulness of doing math projects related to my community is to show my ability to take math outside the classroom. It gives me the eyes to see my community in a different way.	**Rank A – 3** Here the student makes a strong connection between math in the classroom and the student's community. The student notes the value of taking math outside of class and situating it in the community. This is recognition of the porous boundary between the classroom and community. This response represents exactly my goal in teaching math, and in my view is a direct precursor to the highest level of educational attainment, transferring of skills learned in the class to solving problems that affect one's identity group.

Table 4.3 Continued **General Student Survey**		
How can proficiency in math help you, if at all, to manage the career you are interested in?	The ability to understand math is something everyone needs no matter what career they take. Money is what we all live for. You have to pay bills, and buy millions of things you need. The proficiency in math can help you get through these things faster.	**Rank B - 2** This response, though applicable mostly to the individual's personal proficiency, does suggest the importance of a collective proficiency in mathematics as a part of an identity group.
Describe your experience with co-teaching.	Co-teaching is something i really enjoy about Mr. Lucas class. Anytime Mr. Lucas would ask if anyone wanted to go up first, i would jump up real quick. Even though public speaking is one of my low points. I always enjoy getting in front of my class and teaching something to them and also learning while i'm going along.	**Rank A – 2** This response indicates a concern for both individual and collective competency in math.
Do you think co-teaching is helpful for students?	Yes, I do. Because some people get tired of the same person teaching every single day. It gives the students a better chance of learning something because more then one person explains it.	**Rank A – 2** This response extends to collective proficiency.
Describe some important characteristics of a problem solver.	A problem solver is someone who takes extra time to understand something. Sometimes you may come across a problem that seems like their is no way to solve it. But that's where that person who i a problem solver comes along and go way beyond the little things to solve that problem.	**Rank B - 2**This response does not go beyond personal proficiency.

Table 4.3 Continued **General Student Survey**		
Describe any connection you see with math problem solving and your community.	The connection I have with problem is that the more i go along, the more i don't want to just give up. And that makes my close to a problem solver because i try my hardest to solve the problem.	**Rank B - 2** This response does not go beyond personal proficiency. The student's description of a problem solver combined with this response comes close to identifying a problem solver as someone who can be helpful to the community at large, but the response as it is only hints at this role.
Describe the usefulness of using a graphing technology tool in math classes. Describe the usefulness of using interactive technology tools, like webgraphing.com site, Moodle, and Google Docs in math classes.	The usefulness of using a graphing technology tool in math class is that it makes the class more effective. It makes things go by quicker and smoother.	**Rank B - 2**To see how this response may go beyond the level of individual proficiency to group identification, we would have to put this response in the context of the other responses, particularly the ones related to co-teaching. With that in mind, I would interpret this response as saying that technology helps the collective proficiency, (i.e. "allowing things to go more smoothly").
Describe the usefulness of using Maple with your math course.	Maple is an okay program. I don't think it made much of a difference in the class.	**Rank B – 2** To see how this response may go beyond the level of individual proficiency to group identification, we would have to put this response in the context of the other responses, particularly the ones related to co-teaching. With that in mind, I would interpret this response as saying that technology helps the collective proficiency, (i.e. "allowing things to go more smoothly").

Table 4.3 Continued **General Student Survey**		
Describe your comfort level with using Maple.	Maple is a hard application. I find it kind of confusing.	**Rank B - 2** This response indicates a general discomfort level with Maple. My sense is that generally Maple is problematic in terms of its learning curve. I expected this and tried to mitigate it by limiting activity to menu options, as opposed to including inline commands.
Describe how this course may have been different from how you learned math in the past.	This course was different because one my teacher was more interesting in making sure we learn to the best of our ability. He seen more faith in us, then we seen in our self.	**Rank B - 2** This response is the beginning of the student expressing a more positive self-identity as a doer of mathematics, both as an individual and as a member of a math identity group.
Describe how you think the course could have been improved.	I don't think the course needs improvement. It's fine the way it is.	**Rank B-2** I think the previous response clarifies this response.
Summary for this student: The student expressed an increase in his or her math competency. The student identified the use of technology as an essential part of that growing competency. The student hit upon the advantages collaborative technologies affords in deepening student understanding. The student also identified co-teaching a helpful part of that growing competency. The student gave evidence of a local group level identification. The student marginally gave evidence of community group identification vis-à-vis extending the math domain into the community. This is supported by the student's expressed view that math modeling has to be more realistic in order to have an impact on community issues. **Overall Rank: A-2**		

In the survey responses, the majority of students expressed that they experienced an increase in their math competency. Most identified the use of technology as an essential part of that growing competency. Nearly all students identified co-teaching as either moderately helpful or very helpful in increasing their competency. About 80% of students gave evidence of a local group level (math class identity group) identification. They were interested in each other's progress in math and in what way it could contribute to group success. This is a very promising outcome, since this kind of local classroom group identification is a necessary precursor to developing a wider identification as a competent doer of mathematics on behalf of a person's wider community. More than half of the students gave evidence of this wider community group identification, the disposition to extend and transfer math problem-solving skills learned in the classroom into the community. This identification for the most part was in its early stages. The responses ranged from not seeing this potential at all to seeing it passively by observing trends and in a few cases to using information to make decisions proactively. It is my sense that more has to be done by teachers to help students develop the sense that they can use math (that is their developing math skills learned in the class) to affect conditions in their communities proactively and positively.

Research Questions and Opportunities for Further Revelation

I realized that I limited some of my survey questions by using the phrase "in this class." This could have in turn limited the responses of students to just the classroom, whereas, had the question been phrased differently, students may have considered responses that extended beyond the classroom. Taking this into consideration, in the future I would reword the question "Describe the usefulness of using a graphing

technology tool in math classes" to "Describe the usefulness of learning to use a graphing technology tool for math problem solving." I would change the question "Describe the usefulness of using interactive technology tools, like webgraphing.com site, Moodle, and Google Docs in math classes" to "Describe the usefulness of learning to use interactive technology tools like webgraphing.com site, Moodle, and Google Docs for math problem solving." Student survey responses can inform and refine the heuristic of the research inquiry. Asking better questions and using contradictions in responses can lead to a better understanding, in this case, of what is happening when students use interactive technology in math classes and how their learning potential is enhanced.

Contradictions Seen in Responses to Surveys

One contradiction I observed was where two or three students who strongly valued co-teaching (student driven teaching with the adult teacher as an assistant) did not value it as highly when weaker students were demonstrating their knowledge to the class and struggling with their misconceptions. Those few felt this was a waste of class time since the student co-teacher did not know the topic at hand well. I would have thought that a strong value for co-teaching would also engender a tolerance for the sometimes difficult process of weaker students working through their misconceptions about a given math topic. I also thought that the many questions the weaker students had would afford clarifying answers for everyone, including the stronger students. Perhaps the time constraints imposed by the demands of preparing for the standardized state test created an impatience for the often-slow teaching and problem solving process when weaker students served as co-teachers. Without that time pressure, there may have been more patience and solidarity with the co-teaching led by weaker math students. Having said

this, I still would expect that faster students would use this kind of event as an opportunity to learn and reflect on their own math misconceptions.

Another contradiction I discovered with co-teaching is that two or three students who expressed disapproval with co-teaching and interactive technology tools such as Maple also expressed a desire to have more group work. This struck me as odd, since co-teaching and the use of interactive technologies gives students increased freedom to interact as a group amongst themselves with reduced direction from the adult teacher. Perhaps these students were looking for more project-based group work. This could be a further opportunity to do math work that is related strongly to students' lifeworld experiences and community issues.

Regarding students not recognizing the potential for a tool like Maple to enhance problem solving on behalf of the students' identity groups (classmates and community members), the main issue was overcoming the learning curve and intimidation factor of this math program. Again, when there were time pressures due to the demands of state testing, the time available to overcoming the learning curve of a robust math program like Maple was necessarily radically shortened. I anticipate that, when I fully implement the Nspire Navigator interactive technology (a technology for readily sharing student hand-held calculator screens with the class), much of the multiplier effect I expected from using Maple will be realized. The main reason for this is that the graphing calculator use will be more ubiquitous than the use of Maple has been. The expressed dislike for Maple by a few students serves to help establish a focus on mitigating those things (e.g., time constraints due to state test preparation), which impede the easy flow of learning and the process of collaboration to increase the knowledge and understanding of all. This dislike

from a few students does not seem to be a cause for abandoning the use of interactive technology tools for fostering a multiplier effect in the learning process. It was not physically possible for students to use Maple ubiquitously, since they did not always sit by a computer or have a laptop at their desk. In the future they will always have easy access to the Nspire graphing calculator, and so their work on it will be shared with a greater frequency through the Navigator system and smart board. It is now clearer to me that Maple is better suited for projects and special demonstrations – which are still vital parts of math learning – than for more commonly performed tasks that may be more suitably done with a hand-held graphing calculator.

Analysis of Project Products

The example below refers to a project done by a student using either Microsoft-Excel or PowerPoint that evidences her growing identification as a math problem solver.

Paint

One student elected to do a project on a non-violent issue related to her community in contrast to what she felt most students were doing. Her project is included in the appendix and is titled "Paint." She wrote,

> We choose to speak of this problem because it is something rarely spoken of. Most will speak gangs, shooting, and other types of violence's in our community. But we choose to speak of Paint because it is a problem that is rarely spoken of and is a non-violent problem in our community.

Unpacking this statement leads to the surmise that the student identified with this issue with a negligible degree of influence from the teacher. I would never have suggested that the student select this topic as her community issue. For this reason I chose this student's product as an exemplar of what to look for in the product when a student identifies strongly and independently with an issue.

The student selected an issue that is relevant in her lifeworld. She interviewed her father and a businessperson in her community on this issue.

Another indication of strong identification with the issue is that she chose to interview adults on this issue and asked questions that prompted meaningful responses. A further indicator of strong identification with the issue is the care the student took to find specific graphics on the Internet that were appropriate to what she wanted to communicate on each slide of her presentation. This attention to detail supports the claim that she was vested in the issue and communicating the various facets of it. The very first graphic is a powerful example that clearly expresses that the issue is relevant not just to her but also to her community. See figure 2 below for the graphic.

Figure 4.2
Our Community

Though the trend data the student presented does not clearly indicate the rise in prices per capita in her local community, the student clearly intended to try to support her claim with data that she researched. She took the time to find trend data on the Internet and tried to relate it to her local community problem. The student gave further credence to her claim by conducting a rather sophisticated interview with subjects who gave credible corroborating responses. This effort indicates a strong vested interest with the community issue by the student.

The student took pains to demonstrate how she created her regression lines that demonstrated trends on the issue, even though this was not a requirement. It seems that

she wanted to demonstrate how she was empowered to use her new graphing calculator skills to shed light on the issue. Fostering this authorial sense of empowerment is one of the main goals of using technology in the classroom and one of the main goals of co-teaching. The student was allowed to explain the details of her slides, including the steps involved in the creation of the regression lines. Her work so impressed the students on the usefulness of math tools, and how they can be used to analyze issues relevant to the lifeworld of students. The student approached this issue from a small business perspective, keying in on the burden that the increasing costs of purchasing paint for general purposes has on small business proprietors. It appears to me that the student identified significantly with the small business identity group.

The next example refers to another project done by a student using both Microsoft-Excel and PowerPoint that evidences his growing identification as a math problem solver.

The Decline of Home Sales

One student chose a rather sophisticated topic that drew the student to consider deeper factors that might cause the decline of home sales in his community, one being the decline of the national U.S. economy. This is not a typical topic of discussion amongst the students, which lends credence to the claim that the student was not influenced to pick this topic by anyone, including the teacher. This selection expresses a genuine interest on the part of the student and that the student believed that this topic was relevant to his lifeworld. I should note that the student who did most of the work on this project gave some credit to another student. I observed that the second student was ancillary to the first, in that he deferred to the first student on most decisions. It was my feeling that the

first student could have easily done the project on his own, however, I'm sure he appreciated working with the second student, even if it was just to have a sounding board.

Like the topic Paint in the first example above, this topic deals with a non-violent issue and is not a representatively typical choice for most students, which lends credence to the claim that the student identified strongly with the topic of choice and was vested in exploring its various facets. Just like the student with the Paint project, this student elected to interview his father on the issue. The student asked clear and concise interview questions. The student's interpretation of interview responses was also clear and concise. The responses attributed the weakening U.S. economy as a probable cause for the weakening home sales in the student's area in Newark. This clarity, the specificity of interview questions, and interpretations of interview responses by the student suggest a strong level of vested interest in the issue.

There is a strong coherence between the data that the student gathered and the localized community issue that the student researched. This suggests a strong degree of vested interest by the student. A disinterested student may have settled for generalized data that does not really speak to the community issue. The student offered this commentary in his project:

> We agree that the decline in home sales correlates with the decline in the economy but we believe it's safe to say that the crime rate and home maintenance in Newark are also key factors too. We'll take it to the bank that if the crime rate dramatically dropped and there were better housing in Newark there would be more people flocking back to Newark to reside and instead of a negative trend in sale prices there would have been a positive trend instead.

Unpacking this statement, I infer that the student used his own judgment to gauge the soundness of the hypothesis put forward by his father. He then came to agreement with his father's supposition that the U.S. economy is a contributing factor to the decline in home sales within the student's community. The student, however, took the initiative to add his own interpretation, and he added that, "the crime rate and home maintenance are key factors too." The student then said, "We will take it to the bank …" This signifies the student's own committed viewpoint. This contribution is not forced and not simply reproduced from someone else's opinion such as that of the teacher or the student's parents, which points to the development of independent thought and understanding. This is one of the intended payoffs of having students do this kind of project.

The two cases I interpreted above are ones that give evidence of students who have reached the dialogical level of Persuasive and Co-Authorial Negotiation. These are exemplars of what can be achieved when teachers allow the in-class math work to be contextualized by the life-world of students. It is not a given, though, that this level of dialogue will be reached when students are given the opportunity to engage in such projects. This level of involvement still has to be cultivated with the help of culturally sensitive teachers. The next example is a student, who was given the same assignment, and did not evidence this level of dialogue.

Murder

The topic of Murder was selected with a relatively high frequency among male students. This choice could indicate a collective awareness of a serious community problem that most students commonly share in their lifeworlds. However, it can also mask a lack of vested interest in problem-solving issues that relate to the student's

community. The student could simply take a well-documented problem that others are studying and reproduce existing knowledge with little to no independent thinking. I suspect that is the case with this student.

Starting with the first slide of the PowerPoint presentation, the student wrote "I want to know just how much should Newark residents worry about murder (ta. . .ta . . .ta . . .ta. . .ta. . . . . ta)." The inclusion of "(ta. . .ta . . .ta . . .ta. . .ta. . . . . ta)" suggests to me a lack of seriousness and therefore absence of vested interest in the topic. It suggests a continuation of business as usual, a reproduction of existing knowledge. There is no explanation as to why the student selected this problem except to say that he wants to know "how much should residents worry." With this as a goal, there seems little chance that there will be an awareness of how the student can possibly be involved with solutions to this serious community problem.

The interview questions and interpretation of responses were barebones minimum.

Interview with Father:

Q) how long have you lived in Newark?

A) 10 years

Q) Are you satisfied here in Newark?

A) not at all, we live here because of our economic issues.

Q) have you done anything to better Newark?

A) no

The questions were framed in such a way that a simple “yes” or “no” quantitative response would answer them. This does not evidence an interest in uncovering causes of and solutions for the problem.

Interview with a friend:

Q) ayo! you like living in Newark?

A) ahh, it’s not that bad.

Q) have you witnessed any murders?

A) no, but i hear about people getting popped [shot] all the time.

Q) would you like you mind your kids growing up here ?

A) hell yeah !! I don't want Jaden walking around here!

Q) Jaden? you don't even have kids bro

A) that's what I'm naming my first son smart guy!!

me-"oh!"

These questions are also “yes”/“no” kinds of questions. They seem to gauge only the likes or dislikes of the friend as opposed to querying what the causes or possible solutions to the problem are. Asking whether the friend would mind his children growing up in Newark indicates that the issue is not one of contributing to solutions but rather the timing of fleeing from the problem. There is no attempt to give further commentary or interpretation of the interviews showing reflection and independent thinking like that of the student who tackled the housing decline problem. This suggests a lack of vested interest in the problem. In his presentation the student wrote the following.

Interview with teacher:

Q) any comments on Newark?

A) well, my students speak very negatively on this community

Q) why do you think this is?

A) lack of authority, and just fear that something bad is going to happen.

Q) would you live in Newark personally?

A) no, I'd rather not.

Q) do you think anything can be done to help the quality of life in Newark?

A) well, the problem is that someone always is going to get the short end of the stick. If Newark shapes up, then people with money are going to come in, and the lower classes will go elsewhere with the same problems that we have here today.

The student's interpretation of the interview with Mr. Johnson, his English teacher, was more meaningful. The questions were not prompts for simple "yes" /"no" responses. The question about what could be done to help the quality of life in Newark is more indicative of trying to find solutions. The teacher does not offer solutions but rather a deterministic view ("someone always is going to get the short end") on how wealthier classes move in and out of a community presumably based on crime rates. Furthermore, as the wealthier classes move in, he opines, then the lower classes will be forced out along with "their" problems. Chances are, this view of the teacher's would reinforce any view by the student that the solution to having a better community is to flee from the bad one or somehow force out lower class people. Again, the student does not offer up

thoughts of his own, which opens him up simply to reproducing existing ideas such as those of this teacher.

In the concluding PowerPoint slide the student ends with the question, "Currently, murder was on the decline here on the city of Newark. Unfortunately, in 2009 it started to rise again. Should we be concerned?" This indicates that there were no solutions and likely no critical thought co-authored by the student as a result of his inquiry. The student evidences the passive and authoritative level of dialogue**.** Furthermore, there is no evidence that the student is willing to engage in math problem solving that could contribute solutions to the community's problem.

The above projects were done with a combination of PowerPoint and Excel. The next projects were produced using Maple. Maple enables students to mix math computation with free-form descriptive text. This facilitates the student's contextualizing of the math in descriptive terms relevant to his or her own lifeworld experience. The student is able to perform powerful math analysis and couch the results with descriptive text of his/her making, thus providing ample opportunities to re-interpret and co-author knowledge. Students were not as familiar with Maple as they were with PowerPoint. I expected to see them take fewer liberties with adding their own special touches such as adding graphics that can also convey meaning to the project audience. Some students did make an effort to include graphics with their Maple worksheets, but not as many graphics appeared as when students used PowerPoint worksheets.

Teen Pregnancy

The student in this example selected an issue that was relevant in her lifeworld, and that was selected with a relatively high frequency among female students. At the

beginning of the Maple worksheet, she indicated the reason why she chose this topic. “I found this topic very interesting because it is something that I feel like is growing in my community.” See full worksheet titled “teen abortions-1” in appendix. The student placed the interview questions first. My sense is that this student, as with most, enjoyed interviewing community members on their issues and gave meaningful interpretations of those interviews. The interview questions were open-ended rather than “yes”/”no” questions, which indicated that the student was vested in the discovery process.

The student made a telling statement at the beginning, which indicated a strong identification with the problem. “I would really love if these young females learn how to do different things with their life.” The student found meaningful data for African American and Latina females. There is an overall sense that the student identified with these groups, wanting them to as she said in her own words, “do something different” and “live it up,” rather than get pregnant.

At the bottom of the worksheet the student offered a prediction regarding the selected problem scenario.

> My Prediction: “In the future I think that the numbers may go down. From the graphs above you see that the numbers went down. So there is a possibility that it could happen again. Hopefully it will because I am tired of seeing young teens pregnant!”

The student demonstrated that she could illuminate the problem, particularly with her interpretation of existing statistics. She certainly sounded the alarm that she regarded teen pregnancy as a serious issue in her community and showed that she strongly identified with the issue. The sum of all the dialogue in this piece reaches a level of persuasive and preliminary negotiation**,** particularly evidenced by the student’s active interview

questioning of selected community members and apparent desire to develop the discussion. This is an exemplar of what I am trying to achieve with all students. What is lacking in this dialogue is any indication of how, besides documenting the issue, the student could extend the math domain to gain traction on offering solutions to the problem.

I created a simple Maple worksheet that demonstrates the multiplier effect I've referred to in this study as an increasing number of exchanges in dialogue over a given topic. See meaningpotential2.htm file in the appendix. This Maple worksheet was created for a demonstration I gave to my peers at CUNY. The worksheet contains an animation that shows an exponential increase occurs in what I call meaning potential, the meaning people create over a topic, when there is an increase in occasions for people to dialogue about the topic. This idea is central to my claim that we can increase the meaning making, levels of understanding, and ultimately the competency levels of students to do math, by leveraging the collaborative capabilities of interactive technologies. The more we expose students' knowledge to critique, provide students with feedback on their knowledge constructions, and allow students to build upon preexisting knowledge through successive rounds of dialogue with their identity groups, the more they will learn and develop the facility to apply their learning to problems in their lifeworlds. Interactive technologies are well suited to facilitate successive dialog. Furthermore, teachers need to give more thought to how they can give students opportunities to exchange their authored knowledge with stakeholders beyond the classroom. Again, interactive technologies are very helpful for facilitating these more global exchanges, both synchronously and

asynchronously, fostering greater student identity development as doers of mathematics on behalf of their communities.

Chapter 5

Leveraging the Nspire Navigator to Accelerate Math Learning

Nspired Math Navigation In My Classroom

The following is a description of how students in my math classes are currently using the Nspire Navigator, which has been recently introduced to them, and how its use is more ubiquitous than has been the case with Maple. The Nspire Navigator is a wireless network technology that allows for instant sharing of information between a student's handheld calculator, the teacher, and the entire class. The students handheld has an adapter that communicates with a router on the teacher's computer, which in turn can project the student's handheld data to a smart board. Individual students can be a live presenter of their individual calculator display to the entire class at any moment. One feature I use regularly is the capacity to broadcast activity files along with corresponding printed directions that together serve as formative assessments. I download and use free premade activity resources stored on the education.ti.com website, to engage students in inquiry based mathematics, formative assessments, Do Now, and Problem of the Day activities. The resources on the education.ti.com/Math Nspired site are categorized by course, topic, and core standards. The Nspire.tns documents along with the associated pdf file have student and teacher instructions developed with the idea of action consequence. This involves students performing actions on pre-made Nspire activities, exploring the consequences of these actions, and making conjectures. I also create and send to students on the fly, quick polls addressing questions that come up during the lesson. It is akin to

using clickers in the classroom; however, the responses can be in the form of text, graphs, equations, multiple choice selections, or simple true/false answers.

Through the use of the Nspire Navigator the consequences of student responses are captured, aggregated, shared with other students, assessed/graded, and tracked in a portfolio management system. I often review and assess with the class all responses immediately after students submit them. I can mark correct categories of responses that are displayed in a bar graph with just one touch and reveal which students responded in that correct category. Sometimes I wait for a later time to further review and grade the responses. At some point after saving poll results to a portfolio, I select which assessment results to export into the school's existing grading system via an Excel spreadsheet. I use the activity consequence files combined with polling of students to foster student exploration and dynamic visualization of difficult concepts. This gives me another way to reinforce the lesson. Since teachers with advanced mathematics backgrounds created these activity consequence files along with expert software developers, I do not have to always take the time do so. In addition, the activity files are open sourced, meaning that once they are downloaded from a website teachers and students can modify them.

In my math courses, results of using the Nspire Navigator have a multiplier effect on the meaning making in the class, and provides opportunities to make clarifications of misunderstandings students may have on a problem as we dialogue about the submitted responses. The classes are not only more comprehensible due to the dynamic visual activities of Nspire calculators, but these advantages are multiplied through instant feedback afforded by the Nspire Navigator network, coupled with the ensuing whole class dialogue about class results. The tool is a time-saver in many ways because student

work is made more visible when each individual handheld graphing calculator display is revealed on the smart board. I can know what step a student is having a problem with by just glancing at the smart board and locating their calculator display. Furthermore, there is a plethora of resources already available that correlates to just about every math topic covered from algebra to calculus, and this bank of resources is constantly growing. The overall results are that students are more engaged through collaborative activities and instant feedback. This can all translate into enhanced student learning. This technology tool is proving to be an exemplar of how interactive technologies can accelerate the meaning making generated by an increase in dialogue and interactivity between students and teachers.

Piloting Nspire Navigator Use in My Math Classes

I pushed my supervisors to purchase the Nspire Navigator and CX CAS calculators during the prior summer and the early part of the school year. I finally started using the Nspire Navigator and Nspire CX CAS in all my junior and senior classes for the past two months. Prior to implementing it I took advantage of the free webinars on the TI-Education.com website. I managed to get a class set of the Navigator and 20 calculators for myself as well as a set for another math teacher. The total cost for two class sets was about $10,000. Though I encouraged the other teacher to use the Navigator she has yet to move forward with it. Part of the reason seems to be her lack of facility with using new technology. Another reason may be the difficulty of introducing a new calculator during the school year after having familiarized students with the older TI-84. The concern was to not overload junior year students who will take a state test in March

by teaching features of two calculators. I had a similar concern for my juniors who were used to the TI-84 calculator.

For my juniors I decided that I would use the Nspire CX CAS calculators only for communication purposes. That is, I would only use it to poll students on various math problems, and for demonstrations. I would not teach them to perform calculations on the new Nspire calculator. They would have to do all calculations on the TI-84 and when necessary submit their poll responses using the Nspire calculator. If I had enough Nspire CX CAS calculators to issue to all my 40 juniors, I would have dispensed completely with the TI-84. I strictly use the Nspire CX CAS with my seniors, who also have been issued the older Nspire calculator at the beginning of the school year. My seniors for the most part keep their older calculator at home and use the newer one in class. I'm confidant that all our math teachers will eventually migrate over to the Navigator system and the Nspire CX CAS calculators. No teacher has received formal training on these technologies. I have been asked by my supervisor and a math department leader to give a professional development lesson on the Navigator and new Nspire calculator to the all the math departments in our district in the coming weeks.

My students immediately responded positively to the Nspire Navigator and new Nspire CX CAS calculator. My juniors for the most part enjoy the interactivity of responding to instant polls and seeing the categories of responses on the smart board. They enjoy having their names displayed in the category of correct responses. They like to banter with students whose names are displayed in the incorrect categories. I manage this bantering by telling the class that we can learn as much from incorrect responses as we do from correct responses. I make sure then to ask students who answered a question

incorrectly how they came to their answer and do they now understand where they went wrong. This takes the edge off of feelings of embarrassment for answering incorrectly. My students seem to appreciate explaining why they chose an incorrect answer, as well as learning from those incorrect responses.

My seniors particularly enjoy being a live presenter of a calculator task when they have done the task correctly and are asked to demonstrate the task to the entire class. They all appreciate the color distinctions offered on the calculator, as well as the powerful features available to analyze graphs. They have also expressed satisfaction with downloading activity files wirelessly and dispensing with wire connections for downloads. Most students seem to manage the learning curve well and are willing teachers to students who are not as swift in picking up the new features.

Data Analysis of Nspire Navigator Use in My Math Classes

After working with the new Navigator and CX CAS calculators for about six weeks I gave my juniors a survey similar to the one I gave at the beginning of the school year; however, I modified the questions on using interactive technologies by mentioning only the Nspire Navigator technology. I followed this up with more focused questions on the Nspire Navigator, asking students to brainstorm on how they think that this technology can be better used in the class to enhance their learning, if at all. Twenty-seven out of forty students responded to the survey that was given in class on a half day. Here I show a range of student responses to just four questions of the entire set of fifteen. The complete survey with analyses is given in the Excel spreadsheet file JuniorExitSurvey-Navigator-1 located in the appendix.

Table 5.1

Sample From Junior Exit Survey on Navigator Use

	Please describe how your attitude towards math has developed during this course.	Please describe an experience with math during the course that helps explain your current attitude towards math.	Describe the usefulness of using a graphing technology tool like the TI-84.	Describe the usefulness of using the Nspire Navigator with the TI-Nspire calculator.	Describe how this course may have been different from how you learned math in the past.
#1	My attitude towards math changed over the course because i got hooked onto some of the problems as time increased.	it was one day in December that i sat in this math class and couldn't figure out a question, i forgot what the topic was but i couldn't really figure it out. i was really about to give up and tell myself i didn't know the answer but my classmates explained it over and over and i got the answer on my own.	its alright, i don't really use it , i rather use paper and a pencil but its a cool tool.	its a great tool because it shows you what you know and the answers pops up on the board. it makes math that much more fun.	i did more work in this class and i had no choice but to pay attention because i had to go up to the board a lot to answer the questions that were given.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	A-3 This response indicates a collective group identity. This response indicates the student identification with his or her identity group.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B - 2 This response does not go beyond personal proficiency.
#2	My attitude towards math has changed a lot. Math is now a subject of which I enjoy learning.	an experience with math during the course that helps explain my current attitude towards math is when we retake test to see how much we have progress and my scores increase.	it gives students better ideas of graphing.	gives quicker grading, and better communication.	the new calculators improved learning.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 Here the student gives evidence of the growth in competency in mathematics. The student expresses a growing comfort and enjoyment of doing math, which according to James Gee is important to developing competency in any domain.	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B - 2 This response does not go beyond personal proficiency.
#3	My attitude has developed in a positive way. I say my attitude has been developed in a positive way because my overall math skills has been enhancing since i started coming to my 11th grade math class. My attitude makes me stay on task and not give up how I used to in the past. Now I am more focused about my work instead of fooling around.	An experience with math during the course that helps explain my current attitude towards math is everyday in math class. If I don't understand something I don't get all tense I stay relaxed and figure out the problem another way. I realized that math can be answered and figured out in different ways.	The usefulness of using a graphing technology like the TI-84 is that we are getting prepared for any test. I say this because for example I never knew how to use permutations on the calculator but now I understand.	The usefulness of using the NI-Nspire is that it gives me a feel on how I am doing with my math skills. Also as a class we can see how each of us did and see if we understand the concept of a topic.	This course may have been different from how I learned math in the past is that I am more focused. Also the class is more interesting and more laid out as it is being taught.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	B - 2 This response indicates a significant development in personal math competency.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B - 2 This response does not go beyond personal proficiency.
#4	My attitude towards math has not changed during this course i still math is difficult at times and can be easy if i put my mind to it.	The Saturday classes have helped my attitude towards math because it helps polish the skills i forgot i had and help remind me of the new ones that I've learned	The TI-84 helps when i can't calculate a problem on my own, and graphing.	The TI-Nspire is only good for communicating with the teacher when he asks a question.	The teacher actually helps students when they need it and likes to explain everything as best as he can.
Analysis	C - 1 This student is not showing an increase in proficiency in math, nor a proactive approach to learning.	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	B-1 The student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B-1 The student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	No Response given

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

#5	My attitude towards math has developed to a positive perspective. I believe so because I have learned more this in this year's math class then any of my previous math classes. I feel as if the concepts that are taught is well explained and easier to understand.	An experience with math I had during this course that helps explain my current attitude towards math is all the time. All I do is stay focused to the explanations the teacher is showing, and I wouldn't have a problem with the assignments.	There are many things that the TI-84 can do that I am recently being taught about. It can be very helpful in test because it will be much easier and faster to solve a problem.	The TI-Nspire calculator will connect with the class projector so all our answers will be shown on the board when reviewing. I really think there is no point in using that calculator because all you are doing is submitting your answer.	This course is different from how I learned math in the past because it was harder to understand the lesson taught in the 10th grade. In this year math class I understand the concepts taught because the teacher explains them well.
Analysis	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B - 2 This response does not go beyond personal proficiency.	B - 2 This response does not go beyond personal proficiency.
#6	It has developed into me liking it to do.	I like it better than I did in any of my previous classes.	It helps because you can go over your answer to make sure you have a correct answer.	It helped cause we went over the problems that he polled.	My teacher actually makes us understand it way better than any of my past classes.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 Here the student gives evidence of the growth in competency in mathematics. The student expresses a growing comfort and enjoyment of doing math, which according to James Gee is important to developing competency in any domain.	B - 2 Here the student gives evidence of the growth in competency in mathematics. The student expresses a growing comfort and enjoyment of doing math, which according to James Gee is important to developing competency in any domain.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.
#7	In this course my attitude towards math has developed even more than from the first cycle. As we prepare even more for the HSPA, it hasn't been the best cycle but it's been a good way I have learned a lot this cycle more than the first. My attitude has progress even more and I look at math different I get it which helps me a lot and I feel good because I understand math.	An experience with math during the course that helps me explain what current attitude towards math is the recent topic what we done. This topic has helped me and as you can see I get it which is helpful for me and shows how my attitude is and I understand what is going on.	it's really usefulness it helps a lot and I enjoy it a lot because it helps me and saves time.	I love it it's really useful and we save a lot of time in this, He checks our homework and our do nows and we see the right answer its a really helpful calculator.	This course has been different before in math classes because before I didn't pay attention and now i do it's really different from before I didn't learn as much and now i do.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B - 2 This response does not go beyond personal proficiency.
#8	My attitude towards math has developed during this course in many different ways. One, I've strengthen my weaknesses in math such as my algebra I'm not a pro at it but I'm very good. So my attitude towards that is positive. Second I'm still a little weak in geometry but i try to still think positive. So my attitude towards that is a little negative.	My experience with math during the course that helps explain my current attitude towards math is a roller coaster it goes negative and positive for different topics discussed in math.	The usefulness of using a graphing technology tool like the TI-84 is that it gives you details on what your graphing and it is very accurate.	The usefulness of using the Nspire Navigator with the TI-Nspire calculator is that it can help you learn from your mistakes and it allows you to know whether your answer is right or wrong.	This course may have been different from how i learned math in the past because its being broken down by pieces and explained very well and not short handed.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	B - 2 This response indicates a continued growth of personal proficiency in mathematics. A willingness to struggle with the material indicates progress; as opposed to a lack of willingness which indicates no progress	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	B - 2 This response does not go beyond personal proficiency.
#9	Throughout this math course, I feel like I've learned so much more then last cycle. My attitude towards math has increased because now I feel more confident about working with equations and word problems.	What really helps me understand the math topic is when its being taught with examples and especially when it has vocabulary/ terms that come along with it, to make it seem more understandable.	Using the calculator is very useful for graphing because it makes it easier for us to really see the points that are plotted.	Using the Nspire calculator has really motivated me to do my work because now everything we do with that calculator is graded.	This course may have been different from how I learned math in the past because its taught with many examples and the teacher clarifies it by adding in the terms and some extra things.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	B - 2 This response indicates a continued growth of personal proficiency in mathematics.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B - 1 This response does not go beyond personal proficiency.	B - 2 This response does not go beyond personal proficiency.
#10	My attitude towards math has developed during this course because i feel like i am doing better in math that i have ever done in the past and that i am understanding more.	A experience with math during this course that helps explain my current attitude towards math is when the teacher calls us up for co-teaching. I fell more confident in teaching to classmates.	Using a graphing technology tool like the TI-84 help us see math problems in different forms. It also teaches us how to do math on a calculator so that we double-check ourselves.	I don't really like using the Nspire Navigator. Its okay because it grades your problems right when you send it in.	This math course may have been different from how we learned math in the past because i think that the teacher tries to teach us in easy way that we can understand it.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	A-3 This response indicates a collective group identity. This response indicates the student identification with his or her identity group.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.	B-1 Here the student acknowledges the usefulness of technology in helping to understand math concepts. However, there is not a connection with the use of technology as being helpful to the student's math identity group or her community.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.
#11	My attitude towards math has changed a lot. I think i have been more willing to learn in this course of math and im looking forward to everything i have to learn in this class. I have been getting better and I am starting to set higher goals for myself in this class.	When we were still discussing geometry in this course I believe we were talking about Cos Sin and Tan. I was so lost with the number and letters that I wanted to quit. I asked one question that changed my attitude towards the course. I said, "Mr. Lucas, Is Sin opposite over hypotenuse?" And since then I have felt like i am capable of doing any math problem that crosses me because the feeling of knowing something is an Amazing feeling and feel like you are on top of the world.	It is a very visual tool. It helps people see the graph in many different ways and not just on pen and paper.	Nspire Navigator is fun but educational. It is helpful it is very advanced and it can be used in so many ways.	This course is by far the best math course I have had in high school so far. I learn so much and I actually remember it. There is also a lot of interactive learning that helps us remember I would recommend this class to any Sophomore interested in math.

Table 5.1 Continued
Sample From Junior Exit Survey on Navigator Use

Analysis	B - 2 This response indicates a significant development in personal math competency.	B - 2 This response indicates a significant development in personal math competency.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.		A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend beyond the classroom.
#12	My attitude towards math has developed during this course in a lot of ways. The year before i will say that i didn't learn much. My teacher would not go over the work and just give it to us.	An experience that helps explain my current attitude towards math is that co-teaching helped me	The TI-84 was useful because it us a clue on how to	The Nspire Navigator was useful because we would get a poll and when we answer we go over to see who got it right. After that we go over it. It's good because it goes to our grade and it can boost our grade up.	This course was different from how i learned math in the past. The teacher would only give us the work and not explain it. This year we actually did work and the lessons were well taught.
Analysis		A-3 This response indicates a collective group identity. This response indicates the student identification with his or her identity group.	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local collective. This identification does not extend	A-2 This response reaches the level of collective identity. There is identification of graphing tools assisting the goals of the local

			collective. This identification does not extend beyond the classroom.	beyond the classroom.	collective. This identification does not extend beyond the classroom.

In the survey responses, the majority of students expressed that they experienced an increase in their math competency. Most identified the use of the Nspire Navigator technology as being a useful part of that growing competency. About 90% of students gave evidence of a local group level (math class identity group) identification with regards to Nspire Navigator and CX CAS calculator usage. They were interested in each other's progress in math and in what way the Nspire technology could contribute to group success. This local classroom group identification is a promising precursor to developing a wider identification as a competent doer of mathematics on behalf of a person's wider community. However, when asked about Navigator or calculator usage, there was little, to no, evidence of a wider community group identification by students, or the disposition to extend math problem-solving skills learned in the classroom into the community. We have not engaged in full-blown math projects as of yet due to covering a complete curriculum of Geometry and Algebra 2 prior to the state test in March. There was little time to engage in such projects. This will be a priority after the students take their state test.

Two follow-up focused questions were given to the same junior Algebra 2 students specifically regarding the N-Spire Navigator technology. The questions were asked of them at the beginning of their third marking period; so there should have been

less of a concern by students that their responses would affect their grades. The responses were captured in a Moodle course forum and were not anonymous. Students were told that their responses would help shape the practices in math classes going forward. The two prompts were:

1) Describe the usefulness of using the Nspire navigator with math class.
2) How do you think we could use the Nspire navigator to improve our learning experience?

Here, I analyze a few of the responses that demonstrate different levels of student dialogue on the use of the Nspire Navigator using the same method as before. See the appendix file, “Nspire-Focused-Questions”, for the analysis done over all student responses to the two prompts.

Table 5.2
Nspire Focused Questions

	1) Describe the usefulness of using the Nspire navigator with math class. **2) How do you think we could use the Nspire navigator to improve our learning experience?**
1.	The Nspire Navigator is very useful because it gives students a chance to use the calculators for answering questions and it gives them a new way of learning. The way we can use the Nspire navigator to improve math learning is by learning from the mistakes that we make while using it to answer a question and also by comparing our results with other people/ peers in school, so that we can combine and learn from each other.
Analysis A-2	The student expressed an increase in his or her math competency. The student identified the use of the Nspire Navigator technology as an essential part of that growing competency. The student hit upon the advantages of collaborative whole class activities afforded by the Navigator that "combined" to improve all students learning. Knowledge and meaning are obtained through the synthesis of multiple dialogues and points of view, where each utterance (in the Bakhtinian sense) is predicated on those that came before. The student gave evidence of developing identification with the local class group but has not extended that identification to being a community problem solver.
2.	I think the Nspire calculators are beneficial in many ways. I say this because it increases the communication level between students and the teacher. I personally think since the calculators are used to better our math skills through communication we shouldn't be graded on it as much. Overall, the use of the calculators has been a helpful learning experience. Any technology used to better our understanding and skills in math is very much needed and appreciated.
Analysis A-2	The student expressed an increase in his or her math competency. The student identified the use of the Nspire Navigator technology as an essential part of that growing competency. The student identifies increased class inter-communication afforded by the Navigator, as improving learning. I get the sense that the student places this learning on a higher level, being somehow more essential, than other activities that result in a grade. The student gave evidence of developing identification with the local class group but has not extended the identification of being a class problem solver to being community problem solver.

Table 5.2 Continued Nspire Focused Questions	
3.	The Nspire has been very useful in class because it helped us communicate in math class with the polls and trying to understand the new subject we learn in class. It also good for people who don't understand something this can see who has trouble we can see who is having trouble instead of hiding it. Another way the Nspire can help in math class is to see if no one cheats in class and tries to copy off some ones answer so it helps the teacher out.
Analysis A-2	The student identified the use of the Nspire Navigator technology as an essential part of the growing math competency of the entire class. The student indicates that Navigator assists deepening the understanding of students who would otherwise try to hide their lack of understanding. This speaks to the occurrence of a healthy level of dialogue afforded by the Navigator that enhances learning. The student gave evidence of developing identification with the local class group but has not extended the identification of being a class problem solver to being community problem solver.
3.	Using the Nspire Navigator in class makes it way easier and more interesting in class. It gives everyone a chance to interact with each other. We can use it by using the poll feature on it, which lets everyone answer certain questions then review them all together as class. It will improve the class because you can see which topics most people have problems with, this way the teacher will know what to go over more.
Analysis A-2	The student expressed an increase in his or her math competency. The student identified the use of the Nspire Navigator technology as an essential part of that growing competency. The student indicates that whole class activity afforded by the Navigator clarifies class misconceptions on topic, thus improving all students' learning. The student gave evidence of developing identification with the local class group but has not extended the identification of being a class problem solver to being a community problem solver.
	Using the Nspire is very helpful because it makes math class easier. It gives us the opportunity to check our mistakes and interact with my classmates. It also makes the teacher's job easier because the number of correct answers you have could be automatically sent to power school. I believe you can improve on learning math with the Nspire is by the working with you classmates and what their point of view to the question is. Nspire can improve our participation level, our math skills, and how to learn from our mistakes.

Table 5.2 Continued **Nspire Focused Questions**	
Analysis A-2	The student expressed an increase in his or her math competency. The student identified the use of the Nspire Navigator technology as an essential part of that growing competency. The student indicates that the use of the Navigator fosters an increase in sharing different viewpoints on a problem, which in turn enhances learning. Knowledge and meaning are obtained through the synthesis of multiple dialogues and points of view, where each utterance (in the Bakhtinian sense) is predicated on those that came before. The student gave evidence of developing identification with the local class group but has not extended the identification of being a class problem solver to being a community problem solver.
	Using the Nspire Navigator in class makes it way easier and more interesting in class. It gives everyone a chance to interact with each other. We can use it by using the poll feature on it, which lets everyone answer certain questions then review them all together as class. It will improve the class because you can see which topics most people have problems with, this way the teacher will know what to go over more.
Analysis A-2	The student expressed an increase in his or her math competency. The student identified the use of the Nspire Navigator technology as an essential part of that growing competency. The student indicates that the whole class activity afforded by the Navigator clarifies class misconceptions on topic, thus improving all students' learning. The student gave evidence of developing identification with the local class group but has not extended the identification of being a class problem solver to being community problem solver.
	The usefulness of using the Nspire navigator with math classes is it can improve your time limit make me become faster doing the polls. Also after the polls we go over the problems and you can learn from your mistake with what you got wrong. I think we can use the Nspire navigator to improve math learning because we go over each poll and by doing so my math skills will improve and it did. Yesterday we was doing poll of probability I learned from my mistakes. When I did the probability packet it felt easier. This is why i find the Nspire navigator very helpful.

Table 5.2 Continued **Nspire Focused Questions**	
Analysis B-1	The student identified the use of the Nspire Navigator technology as an important part of his growing math competency. The student indicates that whole class activities afforded by the Navigator clarifies his personal misconceptions on topics, thus improving his learning. The student did not give evidence of developing identification with the local class group, nor did he extended his identification of being a problem solver to being a problem solver on behalf of his community.
	The Nspire Navigator helps me to communicate with the teacher. It helps me give my answers to the teacher. I think that the Nspire Navigator could improve math learning by helping us find new strategies and better communication to the teacher.
Analysis B-1	The student identified the use of the Nspire Navigator technology as an important part of his growing math competency. The student indicates that the whole class activities afforded by the Navigator clarifies his personal misconceptions on topics, thus improving his learning. The student did not give evidence of developing identification with the local class group, nor did he extend his identification of being a problem solver to being a problem solver on behalf of his community.
	The Nspire navigator is very helpful for not only the students but also the teachers. It makes it easier for our teachers to grade our stuff straight from the computer. All they have to do is send us a poll mark the correct answer in their computer and BAM! It's graded as soon as we finish our polls. In my opinion the Nspire navigator also helps us improve our math learning cause it intrigues us. The fact that we can do our work on a calculator and use the actual calculator at the same time kind of makes it fun to learn. Well that's just how i feel.
Analysis B-2	The student identified the use of the Nspire Navigator technology as an "intriguing" part of her growing math competency. The student indicates that the facility to do work on the Nspire calculator and posting the results of that work immediately through the Navigator makes learning more fun. Having fun while learning according to James Gee is important to developing competency in any domain. The student provided minimal evidence of developing identification with the local class group, nor did she extend her identification of being a problem solver to being a problem solver on behalf of her community.

Table 5.2 Continued Nspire Focused Questions	
	NSPIRE is useful for class because it is very easy to answer question and communicate with the teacher. I think NSPIRE can be used to take tests since it is very fast to correct them. Therefore, students can see what they had wrong and practice with that concept.
Analysis B-1	The student identified the use of the Nspire Navigator technology as an important part of his growing math competency. The student indicates that the whole class activities afforded by the Navigator clarifies his personal misconceptions on topics, thus improving his learning. The student did not give evidence of developing identification with the local class group, nor did he extended his identification of being a problem solver to being a problem solver on behalf of his community.
	WELL I BELIEVE THE CALCULTOR WE ARE USING NOW ARE USELESS. BECAUSE EVERYTHING WE DO ON THE CALCULTOR WE COULD DO ON PAPER. I FEEL I DIDNT IMPROVE MY MATH SKILLS BY THE USE OF THIS NEW CALCULTOR. I RATHER DO THE POLL MY TEACHER SENTS ON PAPER THEN ON THE CACULTOR BECAUSE THEN MY TEACHER COULD SEE IF I AUTCLLY DID THE WORK OF THE PROBLEM, UNSTED OF PUTTING A, B, C, OR D. ANYBODY COULD JUST ASK SOMEBODY FOR THE ANSWER.
Analysis C-0	The student did not identify the use of the Nspire Navigator technology as an important part of his growing math competency. The student did not view the whole class activities afforded by the Navigator as helping to clarify his personal misconceptions on topics. This student see's the way the Navigator is used as circumventing the one on one attention to the work the student has done on paper to solve a problem. Such attention is traditionally done when the teacher circulates around the room to see how students are doing. It is true that with the Navigator the teacher will do less of this one on one checking. Rather, there is more of a verbal exchange with students across the class. The student did not give evidence of developing identification with the local class group, nor did he extended his identification of being a problem solver to being a problem solver on behalf of his community.

In the survey responses, nearly all of students expressed that they experienced an increase in their math competency as a result of using the Nspire Navigator. Nearly all students gave evidence of a local group level (math class identity group) identification with regards to Nspire Navigator and calculator usage. They were interested in each other's progress in math and in what way the Navigator technology could contribute to group success. The Navigator allowed the whole class to see who answered incorrectly. We established a protocol of viewing the names of those who responded incorrectly to a poll and asking them why they answered as such. Nearly all of the students expressed their appreciation of being able to instantly see how other students responded to a poll. Most expressed that the level of class participation increased as a result of our use of the Navigator. I observed a significant increase in the level of class engagement and solidarity when we used the Navigator. This perception of mine seems to be validated by the survey responses where many students indicated that learning from the mistakes of others, as revealed by the poll results, was important. As one student put it "I believe you can improve on learning math with the Nspire by working with your classmates and what their point of view to the question is. Nspire can improve our participation level, our math skills, and how to learn from our mistakes."

There was a no significant evidence of wider community group identification by students, or the disposition to extend and transfer math problem-solving skills learned in the classroom into wider student communities. I think that to tease out this kind of wider community group identification, more directed questions would have to be asked. In addition, this technology would have to be used in such a way where math activities actually extend beyond the classroom and into student communities. The technology

alone will not foster student identification with community goals. This goal has to be a point of emphasis by the teacher. I will explore this kind of activity more diligently after the state test, which is when there will be more time for projects aligned with this goal of fostering extended community identity development.

There was one response where the student clearly did not identify the use of the Nspire Navigator technology as being an important part of his developing math competency. The student did not view the whole class activities afforded by the Navigator as helping to clarify his personal misconceptions on topics. This student see's the way the Navigator is used as circumventing the one-on--one attention to the work the student has done on paper to solve a problem. Such one on one attention is traditionally given when the teacher circulates around the room to see how students are doing. It is true that with the Navigator the teacher will likely do less of this circulation of the room. Rather, there is more of a verbal whole class exchange in which students, and the teacher can choose to address students who submitted incorrect responses. There is nothing to prevent a teacher from giving this one- on-one attention. For example, I have frozen the smart board screen so that students can't see the responses by others, and after noticing incorrect or no answers, I then went over to students to check on what the problem may be. Since this takes up more time, I admittedly don't do it as often as I do when the Navigator is not used. Now there is nothing to prevent a student from asking to show his solution on the board from time to time; though this particular student has shown some reluctance to do so in any context. His concern is duly noted. Interactive technology can become a buffer that reduces the human-to-human interactivity if a healthy medium is not struck. The pedagogy and teacher goals behind the technology use are indispensible.

I wonder though, if at some point in the near future computer tablets will be readily available to urban students such as mine, where their completely worked out solutions can be recorded using a stylus pen, and subsequently displayed on a smart board with ease. This student's dialogue did not give evidence of developing identification with the local class group while using the Navigator. His response does not give evidence that he extended his identification of being a problem solver individually to being a problem solver on behalf of his community; which was the case with most students. This later observation is a contradiction that needs further inquiry, which I intend to focus on after the state test, when there is more time for larger projects.

Considering this contradiction, I am led to wonder what kinds of dialogue, while using the Nspire Navigator, would evidence a wider community identity development. Furthermore, what kinds of community related math activities would this interactive technology help facilitate accelerated and deeper math learning? What I can say for certain at this point is that students collaborating on a shared space gain access to access multiple viewpoints from each other, thus deepening the levels of dialogue and affording more frequent opportunities to address misconceptions. Certainly this approach to problem solving models collaborative skills required for solving common problems in diverse communities with members having diverse views on a given problem.

All in all the increased levels of interactivity in my junior classes fostered by the use of the Navigator has increased the level of engagement and dialogue about math problems. Knowledge and meaning are deepened through the synthesis of multiple dialogues and points of view, where each utterance (in the Bakhtinian sense) is predicated on those that came before. Students have shown an interest in this interactivity, which is

not dissimilar to the interactivity they experience with their existing out of school social networking. By leveraging their existing culture capital of social networking with class networking activity via the Navigator, we gain advantages towards math learning. The increased whole class dialogue afforded by the Nspire Navigator then can translate into an acceleration of learning.

My study involves using the Nspire is in its early stages. My purpose at this stage is to show what is possible with the use of this particular interactive technology. My aim is to emphasize how an increased level of interactivity afforded by the Nspire Navigator can enhance student learning. However, I must also emphasize that to obtain increased student solidarity and identification with class goals as well as wider student community goals, the teacher has to make these goals a constant focus by engaging students in activities that pertain to these goals. Activities and problems that pertain to students' communities must be presented to students even while they are using technology, in order to foster student identification as being problem solvers on the part of their communities. The use of interactive technology alone without supportive pedagogy goals aligned to those of students' communities by educators does not foster this identity development.

Chapter 6

Ongoing Transformations

Discussion on Transformation | Reproduction | Agency| Aspects of Social Life in Public Schools

In my study and practice of transforming educational environments predominated by African American and Latino students, I have largely focused on the structure | agency dialectic. I've embraced being conscious of macro and meso level structures of society that tend to constrain the educational attainment and life chances of these groups. This focus on having awareness of oppressive structures and awareness of the agentic ways educators can act to transform these structures, producing new structures that are less constraining, has perhaps led me to neglect other equally pertinent aspects of the habitus of learning environments. As I am concerned with production of new structures through agentic actions, I must also give careful consideration to the creation of culture, or structures that occur not through agentic means but through passivity. Tobin and Roth (2006) posit that in learning environments not only is culture produced due to the agency of the participants, but also because of passivity as participants who learn from one another by being with one another in proximity. Tobin says:

> In teaching, we are therefore subject to both agency and passivity, we contribute to making the enacted curriculum as much as being subject to the actions of others and therefore to the events globally. What happens surpasses our intentions. (p. 36)

I also understand passivity to mean the state of being receptive to enculturation or inscriptions of others who contribute to scaffolding the agent's eventual actions. This also has to do with the subtle and not always visible development of identities. Identity formation does not always occur in the active doing by agents, but also in their passive listening and being with another. It occurs in their observations, identifications, imitations, and following others. I must also consider that students and teachers bring ideologies and schema developed throughout their respective ethnic histories to classrooms. These factors impact not only consciously and voluntarily what gets enacted, but also unconsciously and involuntarily what gets enacted. The later is sometimes referred to as second nature or disposition. It is the business of educators to move conscious, liberating practices to the realm of second nature or disposition in their students. The common example in mathematics is the practice and drill of solving problems of a certain type. Teachers hope that by going through these exercises students will commit their newfound competencies to second nature or conditioned response. The hope is that when presented with this problem in some new context students will have the natural disposition to solve them in novel situations, without resort to relearning anew. An uncommon example is the hope of educators that, through instruction in social justice mathematics, students will employ their acquired competencies in mathematics towards the uplift of their communities in an ongoing basis once they graduate.

I have assumed in my teaching practice that, if instructors reflect and focus on the agency side of producing a culture in which students are enacting practices in the math classroom and beyond—especially in instances where they are reaching for their individual and community goals, that the latent, unconscious, passive side of the

dialectical coin will take care of itself. I do recognize that humans have all kinds of conditionings, many of which tend to reproduce relationships that limit their power potentials to reach their goals. I also recognize that despite, educators' best efforts to be conscious of structures that constrain goals and life chances; they are in constant negotiation with these structures. Sometimes they acquiesce to them in the moment so as to get on with a larger project of transformation in a broader landscape. This is like giving up on an immediate battle but not on the larger war. While recognizing the obvious forms of racism that permeate public schools where African American students predominate, I do not necessarily advocate boycotting these schools or refusing to teach in them until such time as they are transformed into being ideal environments for teaching students. I advocate transforming them from the inside out, sometimes with great obvious effect and sometimes with latent, yet potent effect. Sometimes transformations occur deeply on such subtle levels as the passive side of the agency | passivity dialectic.

This begs the question of how best to manage the passive side, integrating it into a holistic vision of a positive learning space where students' self defined goals are achieved. How should educators cultivate it so that it is in agreement with the agentic side? How should they deal with student identity development as competent practitioners of mathematics in support of their goals and those of their communities, when they are not acting in overt or even conscious ways to do so? Enculturation is not always conscious. Habits of mind unconsciously applied, need the precursors of drill and practice in a variety of settings and circumstances. Availing students of the resources and opportunities to effect positive change without always directing outcomes has its place.

The apprentice is not always aware that she is learning from the master, even during some innocuous moment. Students do not necessarily realize that, when they are teaching others they are mastering the concepts as well. Students also do not necessarily realize that, as they are elevating themselves, they are also increasing their potential to elevate their community. Furthermore, this potential for community elevation is no pre-determined outcome of the teaching of content. It is important to monitor and guide students toward applying acquired competencies to uplift (reaching common goals) their communities, without directly requiring them to do so. How do instructors teach students to value not only their individual goals, but also the motives of their communities without compulsion? This is another aspect of passivity. I think one answer is through doing by example. When students see teachers giving selflessly to the school community and loving it, they tend to want to do the same for the school community. This would then become a lasting characteristic of students that they would in turn bring with them to all other fields of their life-world, particularly their community environments.

There is another dialectic, the conscious | unconscious, that needs to be accounted for when trying to transform the habitus of students such that students are better positioned to appropriate resources to reach their individual and collective goals. As Tobin and Roth pointed out, “even in our talking that constitutes the teaching, there are both intentional-volitional and passive elements.” The unconscious is an aspect of passivity. I think this has profound micro level implications for what gets enacted in the classroom. However, it also has broader implications for meso and macro levels of practice that impact the micro level. What happens when administrators, teachers, and

students are not aware of structures that will effectively thwart any real attempts to establish agentic practices on behalf of students?

Suppose for a moment that the movement for national standards and high stakes testing as it is applied to a "school in need of improvement" produces teaching methods that focus on rote learning, teaching to test, and non-critical thinking. Suppose in actuality this focus on high stakes testing eclipses modes of inquiry, critical thinking, and project based-learning that has benefits when it comes to solving real-life problems relevant to the life-world of students; yet only a few teachers and administrators (say one lone math teacher) in the school are consciously aware of this. If this or some other constraining structure is firmly entrenched in unconscious ways, what can the few conscious people do to produce a pervasive consciousness that will begin a transformation of the school environment? In this climate how should these few teach, not wanting to do a disservice to the holistic education of students but also not wanting to be categorized under the existing organization as troublemakers? This is a situation in which an educator needs skill at being inwardly firm to principle yet outwardly flexible. In such a climate it may not be advisable or fruitful to attempt a transformation of the structures that form the environment everywhere and at every time in overt ways. Yet in this scenario, it is clear that not everyone may have compatible goals, or compatible ways of achieving them. In this case, obviously everyone, or every faction, has to decide if the environment in which they operate has enough potential to be transformed in significant ways or whether is it simply intransigent and should be abandoned.

Tobin and Roth posit that "when teaching is considered as cultural enactment, learning to teach is regarded as production, where production involves reproduction and

transformation of existing forms of culture". Given that transformation and reproduction are always present during enactment of all school culture, the question is more of direction, degree and timing when considering how to foster a positive learning environment that helps students reach their goals. Can egregiously constraining structures be transformed into another state that increases students' attainment of educational goals in a reasonable time frame? Since the technological engine of society pushes for ever-broader student competencies, transformation of practices that do not allow students to address such demands within a reasonable time may seem not to be a worthwhile endeavor. Perhaps it is best for conscious educators to coalesce their common vision and focus it on levels, subfields and spaces where there is a greater potential for positive transformation.

Ripple Effect of Micro-Level Transformative Education On Macro-Level Structures

What becomes essential in the deployment of interactive technologies is not the technology itself but the meaning making, liberating ideologies, and problem solving that are all directly relevant to the participants acting for their own benefit and that of the wider collective from which they come. This study has focused on student learning in the math domain; however, what has been learned about using interactive technologies in this domain can be applied generally to the various scientific domains as well. New forms of computer models coupled with increasing ease and power of modifying and sharing these models without regard for distance or time makes possible a broader, more powerful repertoire of pedagogical strategies that can be pressed into service to accomplish common goals of the collective.

In his phenomenological/hermeneutical approach to research Tobin says:

> the methods are adaptive to what we seek to learn and zoom from micro through meso to macro/global as we examine social life in relation to a structural flux that is global in extent and affords local actions as culture is produced in the fields of activity. (p. 82)

In a like manner, I've considered how transformative practices using technology on the micro event level of classroom teaching, can have a larger ripple effect on meso and macro structures that impinge upon what happens on the micro level. Culturally-empowering learning spaces that utilize advanced interactive technologies, coupled with liberating ideologies embedded in the curriculum, have the potential of producing educational experiences for African American students in public schools that are transformative of existing constraining structures in public schools, affording agency for both individuals and collectives. These spaces are not isolated enclaves that locate the problems facing African American students in the individual attitudes of the students or in their ethnic practices. Rather, there is a recognition that agency of students is interlinked with how students and stakeholders access and manage available resources of the larger society to construct meaning and knowledge that can be applied to their collective problems and motives. These learning spaces can serve as models for public education not only for minority students but also for all students. In particular localities they can have a transformative effect on meso and macro level structures of education and society as a whole. Sewell (2005), in his Logics of History, conceives of meaningful events as

> [s]equences of occurrences capable of causing transformations in existing structures. … Most events are neutralized and reabsorbed into preexisting

> structures in one way or another – they may be forcibly repressed, pointedly ignored, or explained away as exceptions. … An occurrence only becomes a historical event when it touches off a chain of occurrence that durably transforms previous structures and practices. (p. 227)

I believe that the enactment of transformative education through the construction of culturally empowering learning spaces locally, can have a cascading and enduring transformative impact on how education is practiced on macro and even global levels, in public education. Jonathan Turner's (2007) cultural theory helps to conceptualize how such a transformation of educational practice can be initiated from local levels to meso and macro levels. Turner expresses this concept of social change through emotionally charged actions emanating from the micro level of the human encounter, and cascading through meso and macro structures.

> [e]motional arousal at the level of iterated encounters spreads through networks of meso structures, changing key corporate and categoric units or perhaps creating new meso-level structures, that change macro level structures. … For most encounters however, the culture of meso-structures is reinforced and reproduced which in turn, sustains culture at the macro level of social organization." (p. 73)

It is my hope that this study will support the creation of culturally empowering learning spaces, and that the accumulated knowledge capital that it produces, will touch off cascading series of meaningful events that will durably transform educational practices so as to help minority students reach their self-defined goals. It is my hope that such a model project of creating culturally empowering learning spaces, and the accumulated

knowledge capital that it produces, will touch off cascading series of meaningful events that will durably transform educational practices.

The exponential advances in technology are changing the ways it is possible to address the ongoing issue of racism and its various manifestations of oppression. It is imperative to recognize that these changes are speeding up the movement towards a situation where African Americans collectively will not develop the survival tools necessary to avoid becoming a permanent underclass or an irrelevant factor in society as a whole. Closing the achievement gap faced by lower achieving groups can teach valuable praxis for closing the achievement gap between America and other countries that have surpassed America in student achievement. Perhaps if educators of good will can bridge the technological learning gaps faced by minorities, the larger society will also be able to bridge economic and social gaps thus promoting a greater American society with equal opportunity for all.

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