An Analysis of Teacher Defined Mathematical Tasks: Engaging Urban Learners in Performance-Based Instruction

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This is an investigation of secondary mathematics teachers' understanding of performance-based tasks with respect to the contextual design of tasks that promote urban students' engagement and pursuit in learning mathematical concepts. We examined the alignment of teacher designed tasks with their personal definitions of tasks; then further analyzed the teacher designed tasks with respect to the literature on effective performance-based tasks and culturally relevant pedagogy. We found after a yearlong engagement in professional development teachers were able to analyze tasks for cognitive demand. However, the teachers were not as adept in creating culturally relevant tasks of high cognitive demand.

Introduction

For almost two decades there has been a movement within the mathematics education community to implement standards-based/performance-based instruction in all mathematics classrooms (National Council of Teachers of Mathematics, 2000). While this movement has been in existence, the need for research addressing the challenges of and pathways to implementing standards-based instruction—especially in urban classrooms—is crucial. Lack of performance-based instuction that is culturally relevant has marginalized urban learners' capacity to effectively engage in learning activities that require significant cognitive effort (Martin, 2000). Consistently, literature addressing urban education states urban learners look for challenging situations that connect to real-world contexts. They want to see the "big picture" and how the curriculum will relate to future endeavors. Teaching for conceptual understanding provides a means of increasing the learners' critical thinking skills, connects concepts to real-world contexts, and creates a learning environment that shows the continuity of mathematics instead of discrete segments (Gay, 2002; Howard, 2003). Thus, this research study was designed to examine urban secondary mathematics teachers' understanding of performance-based mathematical tasks. The research questions for this study are: how do teachers of urban learners define performance-based tasks and how do their definitions manifest into their design of tasks?

Background

After a thorough examination of its mathematics curriculum, the Georgia Department of Education found the Georgia Quality Core Curriculum (QCC) to lack rigor, be inadequate, and not meet national standards for mathematics teaching and learning. Therefore, Georgia designed and implemented a performance-based curriculum in mathematics. Across the United States, specifically within Georgia, teachers are being asked to make a paradigm shift in the content they are presenting in their mathematics classrooms, their way of delivering instruction, the way in which they engage and provide feedback to students, and the depth to which to teach the materials.

> The Georgia performance standards for mathematics have been designed to achieve a balance among concepts, skills, and problem solving. The curriculum stresses rigorous concept development, presents realistic and relevant tasks, and keeps a strong emphasis on computational skills. At all grades, the curriculum encourages students to reason mathe matically, to evaluate mathematical arguments both formally and informally, to use the language of mathematics to communicate ideas and information precisely, and to make connections among mathematical topics and to other disciplines (Georgia Department of Education, 2006).

In teaching Georgia's QCC for high school mathematics, teachers teach courses that are content specific, e.g., Algebra 1, Geometry, Algebra II, Statistics, and Advanced Algebra and Trigonometry. With the implementation of the Georgia Performance Standards (GPS), teachers will teach integrated courses. Each of these courses will contain content strands from Algebra, Geometry, Numbers and Operations, Measurement, and Probability and Data Analysis. This integrated approach to teaching mathematics will require that teachers enhance their pedagogical skills and pedagogical content knowledge (Shulman, 1986) in making mathematical connections across the content strands.

Teachers will also need to be skilled in applying various pedagogical methods to facilitate deep conceptual understanding within their students. According to Shulman (1987) and Hill and Ball (2005), teachers must have command of the subject matter. Thorough understandings of the mathematics will enable teachers to be flexible in addressing students' needs and connect the material to real-world situations. Through appropriate pedagogical content knowledge, a specialized pedagogical practice specific to teaching content, and proficient knowledge of the mathematics needed to teach, teachers will be able to impact students in a profound way (Ball & Bass, 2000; Shulman, 1986).

> The implementation of this [GPS] curriculum will require that mathematics classrooms at every grade be student-focused rather than teacher-focused. Working individually or collaboratively, students should be actively engaged in inquiry and discovery related to real phenomena. Knowledge and procedural skills should be developed in this context. Multiple representations of mathematics, alternative approaches to problem solving, and the appropriate use of technology are all fundamental to achieving the specified goals of the curriculum (Georgia Department of Education, 2006).

With respect to our focus on the impact of mathematics teaching and learning on the performance and achievement of urban learners, we became proactive in implementation of the GPS in urban classrooms. Our response was in the design and delivery of a professional development project. The professional development, in which this study is situated, engaged secondary mathematics teachers of urban learners in amelioration of their pedagogical choices and practices. This included a weeklong, summer intensive workshop followed by monthly meetings during the academic year. Teachers were immersed in activities to strengthen their knowledge of and practice in performance-based mathematics instruction. Activities included an examination of the literature on urban learners, performance-based mathematics teaching and learning, culturally relevant teaching, and mathematical tasks. The teachers were engaged in designing, analyzing, and modifying mathematical tasks with respect to the literature and their experiences as teachers of urban learners. They participated in a case study of classroom practice to facilitate their discussion and analysis of performance-based tasks and effective mathematics instruction and reflected on their teaching practices. They were also immersed in rich learning of the content necessary for classroom implementation of the GPS.

Conceptual Framework

Three frameworks provide a foundation for this study: effective performance-based tasks, the Mathematical Tasks Framework (MTF), and the tenets of culturally relevant pedagogy. Performance-based tasks serve as a context for student learning (Doyle, 1988; Stein, Smith, Henningsen, & Silver, 2000). Simply putting students in groups does not create opportunities for student learning, nor by giving them a calculator or manipulatives; instead, the level and kind of thinking students encounter determines what they will learn (NCTM, 2000). Thus, the appropriate performance-based task must be selected to accomplish the intended learning goals. A *performance-based task* is an enriched activity that has multiple pathways to a solution, and it requires the students to demonstrate their mastery of multiple integrated standards (Glatthorn, 1999). According to Suzuki and Harnisch (1995), performance tasks should embody five criteria. These criteria include (a) replicating real-world events, (b) having various pathways to reach a solution, (c) demonstrating the continuity of mathematics instead of discrete segments, (d) providing a space for students to communicate understanding of the concepts, and (e) having a rubric for clear explanation of expectations. The MTF provides an adaptable approach for teachers to use in examining the cognitive effort required of students in order to achieve success in completing an assigned task. Culturally relevant pedagogy integrates real-world scenarios with academic content by providing situations that connect to the learners' environment; it challenges learners to solve non-routine problems situated in the students' culture (Gay, 2002; Howard, 2001, 2003; Ladson-Billings, 1995).

Methodology

The participants of this study were 30 secondary mathematics teachers who were selected by their respective principals to participate. The demographics of this group of urban teachers were: 21 females and nine males; of the females there were 17 Black females, three

White females, and one Asian female; of the males there were seven Black males and two White males. These teachers taught algebra, geometry, calculus, and statistics. Data were collected from all 30 teachers. Through purposeful sampling, we selected five of the teachers as case studies. Among the 30 teachers, this group of five was in attendance at every session of the professional development and completed all phases of data collection. They were one Asian female, three Black females, and one White male.

Data collection included an open-ended survey, constructed tasks, and self-analysis of constructed task. At the beginning of the professional development workshop, teachers completed an open-ended survey to assess their initial understanding of the definition of a task. The survey provided baseline data on the participants' knowledge of performance-based tasks. Constructed tasks refer to the process of tasks creation, analysis, and revision. After completing each task, the teachers deconstructed the task for the mathematics needed to successfully complete the task, misconceptions that may arise with students, the level of cognitive demand of the task with respect to the Mathematical Tasks Framework, and cultural relevance.

Results/Analysis

We examined three elements: teacher's definitions of task, their ability to construct performance-task of high cognitive demand, and their ability to create these tasks with that are culturally relevant. Teachers purposefully selected for the case studies, *Angie, Debra, Catherine, Cevia, and Kyle*-- here after referred to as participants-- designed tasks aligned with their personal definition of a performance-based task. After participating in this professional development, evidence of understanding some aspects of performance-based tasks were found in tasks designed by *Angie, Kyle, and Catherine.* The participants' ability to design tasks that meet the criteria of performance-based tasks that align with the tenets of culturally relevant pedagogy was minimal. Most of the tasks created did not have a connection to culturally relevant instruction. Culturally relevant instruction poses questions that stimulate critical reflections on the mathematics in connection with the students' environment. The tasks were connected to real-world phenomena, but not to specific occurrences that students could relate to their current situations nor to their cultural upbringing. However, the participants' ability to categorize tasks by their level of cognitive demand was heightened.

Cultural relevance

The participants' thought they were engaging in culturally relevant practices, but did not have the theoretical knowledge to support it. As the definitions of culturally relevant pedagogy emerged, participants would reply, "Oh, I do that" or "Well of course; it makes sense for our students." However through the tasks deconstruction process, participants only identified tasks that would probably be of interest to young African-American students, i.e. contexts in music, sports, or film, as culturally relevant. Tasks that involved politics, events that may raise the social consciousness of the students (Gutstein, 2006), or accessed students' prior knowledge were not identified as culturally relevant. This phenomenon persisted as the participants constructed their own task. Only one participant constructed a task that displayed elements of incorporating students' interest, along with prior knowledge, student authentication, and a connection to the community.

Mathematical framework

Through participation in guided practice of determining the cognitive demand of a task, all 30 teachers became more confident in determining if a task was on a high level (e.g., doing mathematic or procedures with connections) or low level (e.g., procedures without connections, or memorization). After constructing their own task, all five of the participants classified their task as either doing mathematics or procedures with connections which are both considered high cognitive demand levels. An analysis of the constructed tasks revealed that three were of high cognitive demand while the other two obtained a level of procedures without connections, a lower cognitive demand level.

Alignment of definitions with constructed tasks

With respect to the five criteria for an effective task, we found the participants' definitions lacked elements of real-world scenarios, multiple pathways to a solution, mathematical continuity and opportunities for students to communicate their understandings of mathematics. Once the participants completed the professional development, four of the five participants constructed tasks that demonstrated all or most of the characteristics of an effective task.

Tables 1 through 5 provide each participant's definition of a task, followed by the participants developed tasks, then our analysis.

The analysis is developed with respect to: how do teachers of urban learners define performance-based tasks and how do their definitions manifest into their design of tasks.

Table 1

Angie's Definition and Task

(Asian Female)

Action	Response
Task Defined	The class activity that helps students to master the objective.
Task	The task used by Angie was one created by M. B. Ulmer (1999). Given the question, "What is the largest number of pieces you can get from a sandwich with cuts of a cleaver?" Students will be given a worksheet that has pictures of sandwiches to make X cuts. They will fill out a chart that is provided on the worksheet and then use this information to test which function family best models the data. Students will then explain and verify their choices.
Analysis	In her definition of a task, Angie describes characteristics of the type of pedagogical strategies required for teaching Georgia's QCC. She remains focused on mastering objectives as opposed to students meeting standards. Her task shows understanding of non-routine problem solving and required students to explain their answer thus communicating their understanding of mathematics, but lacks context for urban learners. Therefore, after engagement in this initial phase of professional development, Angie's description of tasks and her designed task remain consistent with the approaches to teaching and learning mathematics under the QCC.

Table 2:
Kyle's Definition and Task
(White Male)

Action	Response
Task Defined	A task is something to do, quite literally. It requires an active participation from those performing the task.
Task	You have been working in acting for several years and now your payday had come. You are about to be signed by a big production studio and are promised a third tier contract. The studio gives you three options from which to choose. The first gives you a handsome signing bonus of $1,000,000 and $150,000 per film. On the second plan, you would get $250,000 per film but a signing bonus of only $100,000. The first two options promise you 3 films a year for 4 years. The third plan offers neither a signing bonus nor per-film pay, but will pay you one-half of one percent of all the profits from each film. You will have to research the studio's track record of profits from their films over the last 5 years. Make your decision based on the data.
Analysis	Kyle's definition of a task indicates his understanding of a performance-based curriculum in that students actually "do something" through active participation. The task is high in cognitive demand because there is not an explicit pathway for a solution and student interest is considered. Mathematical continuity is maintained through the use of multiple strands of mathematics and students' prior mathematical knowledge must be accessed. Thus, this task was classified as culturally relevant.

Table 3
Debra's Definition and Task
(Black Female)

Action	Response
Task Defined	A task is an activity based on performance objectives which indicates the understanding of the desired outcome
Task	Each pair of students was given four problems that dealt with logarithmic functions. The problems were taken from the text and ranged in difficulty level and type. Some problems required changing an expression from exponential to logarithmic form (and vice versa); some required the students to use laws of logarithms to simply expressions and solve equations; and some were applications of logarithmic functions. Each pair was given four different types of problems. After about 20 minutes, students were to present their problems to the class. They were to provide explanation as to how each problem was solved and were to be prepared to answer any questions that were posed. The only prerequisite was for them to read and take notes in the section. There were no direction instructions.
Analysis	Debra's task is embedded in traditional instruction. It does not possess any of the components of an effective task or cultural relevance. Students will use specified algorithms to solve the problem, lowering the cognitive demand.

Table 4
Catherine's Definition and Task
(Black Female)

Action	Response
Task Defined	Open ending, standards-based assignments. Usually hands-on, real-world application/ problem.
Task	Cameras, telescopes, and surveying equipment all have tripods as stands. A tripod has 3 legs. The length of the legs can be adjusted. Do you think three legged stands are better than four legged stands? Why or Why not?
Analysis	Catherine's definition of a task and her task as designed are incongruent. Her task does not address any aspects of performance-based teaching. It is not clear what she expects to students to do mathematically in order to approach the problem. Rather than being open-ended the task is not clear. Context is included in the task, but it does not align with the tenets of cultural relevance as outlined in this study. Students have an opportunity to express their reasoning; thus the level of cognitive demand is high.

Table 5
Cevia's Definition and Task
(Black Female)

Action	Response
Task Defined	A detailed objective stating what you would like the students to learn/ obtain from the lesson/ unit.
Task	Solving a three variable equation – Choose two equations and eliminate a variable. Choose two more equations and eliminate the same variable. Using the two new equations from steps one and two, eliminate another variable and solve for the last variable. After solving for a variable, substitute the value back into equations one or two from steps one or two and solve for the remaining variable in that equation. By this step, you should know the values of two of the three variables. Substitute the values of the two variables into your original equations and solve for the last variable. Write the answer as an ordered triple.
Analysis	Cevia's example of a task is direct instruction for solving equations. It is apparent that Cevia has not developed knowledge of mathematics teaching and learning from a performance-based perspective. While Cevia's definition of a task and her task are consistent, they are not within the realm of the components of performance-based instruction.

Conclusion

Keeping in mind, these teachers are shifting from an objective-based to a performance-based curriculum, it is evident from this study that to impact a paradigm shift in the teachers' ability to create high cognitive performance-based tasks that align with the components of culturally relevant pedagogy will require an extended period of professional development beyond a one-year long period. These findings provide implications for further studies. Further studies designed to investigate factors that may affect teachers' abilities to develop culturally relevant tasks for urban students are warranted.

As fore mentioned, the Department of Education is calling for students to have the ability to problem solve and provide multiple representations with contextual situations. When students are motivated by the mathematics, they are more apt to engage more intensely in the problem solving process (Ladson-Billings, 1997; Kopetz, Lease, & Warren-Kring, 2006). Culturally responsive teaching offers the context that empowers students in meaningful scenarios that are rel evant to their lives. This project sought to capitalize on culturally responsive teaching in meeting the request by the department of education.

References

Ball, D., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning*. Westport, CT: Ablex Publishing.

Doyle, W. (1988). Work in mathematics classes: The context of students' thinking during instruction. *Educational Psychologist, 23*(2), 167 - 180.

Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of Teacher Education, 53*(2), 106 - 116.

Georgia Department of Education (2006). *Mathematics curriculum revision: Executive summary*, Retrieved October 2007, from Georgia Department of Education, Georgia Standards http://www.georgiastandards.org/math.aspx.

Glatthorn, A. A. (1999). *Performance standards and authentic learning*. Larchmont, NY: Eye on Education.

Gutstein, E. (2006). *Reading and Writing the World with Mathematics: Toward a Pedagogy for Social Justice.* New York: Routledge.

Hill, H., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371 - 406.

Howard, T. (2001). Powerful pedagogy for African American students. *Urban Education, 36*(2), 179-202.

Howard, T. (2003). Culturally relevant pedagogy: Ingredients for critical teacher reflection. *Theory into Practice, 42*(3), 195 - 202.

Kopetz, P., Lease, A, & Warren-Kring, B. (2006). Comprehensive urban education. Boston, MA: Pearson Allyn and Bacon.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant teaching. *American Educational Research Journal*, *33*, 465–491.

Ladson-Billings. G . (1997). It doesn't add up: African American students' mathematics achievement. *Journal for Research in Mathematics Education*. 28(6), 697-708.

Martin, D. B. (2000). *Mathematics success and failure among African-American youth: The roles of sociohistorical context, community, forces, school influence, and individual agency*. Mahway, New Jersey: Lawrence Erlbaum Associates.

National Council of Teachers of Mathematics. (2000). *Principles and standards of school mathematics*. Boston: National Council of Teachers of Mathematics.

Shulman, L. (1986). Paradigms and research programs in the study of teaching: A contemporary perspective. In M. C. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 3 - 36). New York: Macmillan.

Shulman, L. (1987). Knowledge and teaching: Foundations of new reform. *Harvard Educational Review, 57*(1), 1 - 22.

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development*. New York: Teacher College Press.

Suzuki, K., & Harnisch, D. (1995). Measuring cognitive complexity: An analysis of performance-based assessment in mathematics, *Annual Meeting of the American Educational Research Association*. San Francisco, CA.