

Building elementary school teachers' cultural competencies through co-design of mathematics tasks.

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Research shows students' mathematics knowledge is tied to their cultural practices and students perform better on tasks that are linked to their everyday experiences (Thanheiser & Koestler, 2021). The lack of connection between school mathematics and student everyday lives diminishes student interest in mathematics as early as in upper elementary grades (Putwain et al., 2018). This has an even larger impact on students from sociocultural groups who on average lag behind their peers (Edwards & Parada, 2022). Schools need teachers who are aware of students' cultural 'norms' and experiences in order to influence their learning. However, few tools are available to explicitly support teachers' development of culturally relevant pedagogy (CRP, Ladson-Billings, 2000) competencies within their daily planning and implementing mathematics lessons (Mark & Id-Deen, 2022).

In order to address this challenge, we developed a PD program that engaged teachers in co-designing (with researchers) mathematics activities, linked to everyday interests and culturally informed prior knowledge of Black and Latinx students in urban elementary classrooms.

Background

Our study is framed by sociocultural theories of learning that define learning as experiential, situated, and contextual. Mathematics knowledge in the situated perspective is understood as being co-constituted in a community within a context. Thus, our project provided teachers with participatory learning experiences through the lens of two frameworks: culturally relevant pedagogy (Ladson-Billings, 1995) and design thinking (Rinke et al., 2016).

Ladson-Billings' (1995) seminal work with elementary teachers led to conception of a CRP as teachers' "ability to develop students academically, ... willingness to nurture and support cultural competence, and ... development of a sociopolitical or critical consciousness" (p. 483). Further, Matthews, Jones, and Parker (2022) developed a culturally relevant mathematics task-building framework to explore the core concepts of *demand*, *relevance*, and *agency*. These concepts – with their attention to meaningful and rigorous mathematics – aligned with the goals of our project and informed our work building authentic tasks to enhance student learning. *Demand* centers on the importance of building deep conceptual knowledge and further entreats students to do mathematics and construct mathematical knowledge. *Relevance* is meant to embed mathematical inquiry in students' cultural knowledge and identities. *Agency* incorporates the concepts of empathy and social action within mathematical contexts.

Design Thinking is a dynamic problem-solving framework that can empower educators to develop engaging and effective curricula (Brown, 2008). In educational contexts, design thinking emerges out of social processes and involves creation of knowledge. According to Summerville and Reid-Griffin (2008) design thinking should be treated as a process in which social exchanges move ideas back and forth until these ideas are fully accepted by the team.

Acknowledging the importance of CRP and teacher involvement in curriculum design, and noting that these elements are often missing from teachers' PD experiences, we placed the co-design of culturally relevant mathematics activities at the center of our teacher PD program.

Methods

The case study was guided by the following research questions: 1) How does co-designing culturally relevant mathematics activities influence teachers' perceptions of and competencies in culturally responsive mathematics pedagogy (CRMP)? 2) What core concepts of CRMP, i.e., demand, relevance, and agency, are demonstrated by teachers in the mathematics activities they co-designed with researchers?

Participants were two teachers, Deja and Sharon (pseudonyms), who were teaching in the same Integrated Co-Teaching (ICT) classrooms in a NYC Title I public schools. ICT classrooms are those where a general education and a special education teacher jointly provide instruction to a class that has students with and without disabilities. In their school, 46% of students are identified as Black and 49% as Latinx; 24% of students have disabilities, and 93% of students receive free lunch. Deja is a Black female general education teacher with 15 years of teaching experience. Sharon is a Black female special education teacher with 20 years of teaching experience.

The teachers and researchers each took the lead in designing 25 activities, totaling 50 mathematics activities that included culturally relevant scenarios. The PD program included a 3-day summer retreat and co-design workshops conducted during the school year. In total, teachers participated in 18 hours of in-person PD during the summer, 18 hours of in-person and 15 hours of online PD during the school year. The summer workshops were led by faculty-experts in mathematics education, urban and minority education, and CRMP, as well as professional staff - experts in curriculum development. During this time teachers selected instructional units for supplementing standards-based mathematics curriculum with culturally relevant activities. During the Fall PD, teachers explored how mathematics activities might incorporate CRP principles. During the Spring PD, teachers in collaboration with the project team co-designed activities for the selected instructional units.

Teacher focus group interviews were conducted in-person during the summer retreat. Individual teacher interviews were conducted online in January, about half-way through the study. All interviews were semi-structured and followed a pre-made script with open-ended questions. Focus group interviews included five questions about teachers' expectations from the project, their experiences in teaching mathematics and their students' experiences in learning mathematics. Individual interviews included four questions that focused on teachers' thoughts about CRMP and future implementation of the developed activities. The individual interviews also probed teachers' early PD experiences in co-designing activities.

In order to code interview transcripts and ethnographic notes we developed the *Codebook for CRMP Competencies* (Table 1) based on the framework for culturally responsive teaching (Muniz, 2020)

Table 1. CRMP Competencies

Framework competencies	Code
Recognize and redress bias in the system	RB
Draw on student's culture to shape curriculum and instruction	SC
Bring real-world issues into the classroom	RW
Model high expectations for all students	ME
Promote respect for student differences	SD
Reflect on one's own cultural lens	OL
Additional competencies	Code
Acknowledge school style	SS
Recognize parent's background in mathematics	PMC
Acknowledge student differences in mathematics	SM

CRMP Rubric (Table 2) was developed based on Mathews et al. (2022) mathematics tasks building framework in order to assess the co-designed activities. The rubric incorporates the three core aspects of *demand*, *relevance*, and *agency*, with adaptations aligned to the template the project team designed for the development of activities.

Table 2. CRMP Rubric.

CRMP Components	Criteria
<i>Demand</i>	Opening scenario is clearly written: mathematical question is clear and correct, even if open-ended
High = 3	Mathematics required is at or above grade level

Medium = 2 Low = 1	Task (either in the opening scenario or in the reflection) has an element that allows for meaningful student exploration and thinking OR extends the mathematics explored in the task to a new or novel situation
Relevance	Scenario references a cultural or community or familial context, in a non-essentialist/non-stereotypical way
High = 3 or 4 Medium = 2 Low = 1	- Scenario presents mathematics within the cultural/community/familial context in a meaningful, authentic way - Scenario affirms and/or reflects attention to students' identities within and/or beyond school - Scenario makes use of students' knowledge and experiences
Agency	Scenario prompts students to think about taking action to benefit or contribute to others or society, either locally or broadly
High = 2 Medium = 1 Low = none	- Scenario prompts students to engage in empathetic thinking or reflects empathetic behavior - Scenario prompts students to consider issues relevant to social consciousness, equity, and/or justice

Results

In order to facilitate the co-design process, the researchers designed an activity planning template. In addition to common elements of mathematical tasks (such as objective, materials, procedure) the template also included several components unique to the B-squared activities: developing a scenario, incorporating a mathematical prompt, and providing reflection questions for students. Scenarios, mathematical situations to be explored, were to be engaging and of interest to students. For each scenario, and accompanying mathematical prompt and reflection questions, teachers were to consider demand, relevance, and agency, that are characteristic of rich culturally relevant mathematical tasks. These three concepts, incorporated into the activity planning template, and the corresponding rubric (Table 2) supported the teachers in the co-design process.

Deja and Sharon completed four activities in February, five in April, eight in May, and eight in June. These activities were assessed using CRMP rubric and Figure 1 shows the average monthly scores for demand, relevance, agency for these activities.

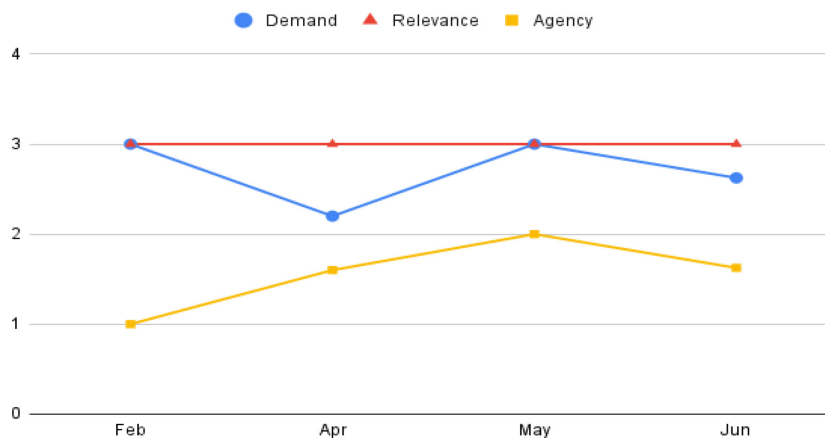


Figure 1. Demand, relevance, and agency average monthly scores of activities developed by the teachers.

As seen from the graphs, all activities included scenarios that were relevant to the students, representing teachers' competency in student culture. The demand scores that indicate teachers' knowledge for teaching mathematics fluctuated, as teachers often used close-ended problems that did not include meaningful explorations for students. These also reflect that teachers' ability to create high demand scenarios depended on their facility and familiarity with the topic. The agency component was the most difficult aspect of culturally relevant pedagogy for the teachers.

Summary of findings from focus group and individual interviews is presented in Table 3.

Table 3. *Participants' CRMP competencies (FG – focus group, II – individual interview)*

Code	Deja	Sharon
RB	FG: linked learning gaps to students' low reading comprehension that had a direct influence on mathematics achievement FG: differentiated between bias at the individual level and institutional racism	FG: blaming students for their low academic performance II: no longer blaming students for low academic performance, but was looking for opportunities to support them
SC	FG: drew on her students' culture II: demonstrated variety of competencies in understanding student culture	FG: demonstrated variety of competencies in understanding student culture II: an increase in her understanding of student culture and how that can shape mathematics curriculum and instruction
RW		FG: emphasized importance of bringing real-world connections into the classroom
ME		II: stronger beliefs in student abilities as they explore mathematics demonstrating higher expectations of her students
SD	FG: demonstrating her respect for student differences	
OL	FG: understanding that teachers need to better develop their own cultural lens II: shifts in perceptions and attitudes toward her own mathematics learning and instruction; beginning to show development of her own cultural lens	FG: reflecting on her lack of confidence in using classroom technology and her own ways of learning II: reflecting more on her own learning in connection to CRP.
SS	FG: concerned how school expectations and norms may limit new culturally responsive instruction II: concerned about integrating activities into a rigidly structured curriculum that is already at full capacity	FG: difficulty imagining how open-ended activities could support student learning of standards-based mathematics
PMC		FG: perception of a lack of attention to mathematics in the families of her students
SM	FG: acknowledge student difficulties in mathematics performance	II: recognized that some underserved students may have mathematical difficulties, demonstrated belief in their success with proper teaching

As can be seen from these results, after the PD, Deja and Sharon developed broader competencies related to student culture (SC), and started to develop and reflect on their own cultural lenses (OL). Deja continued to have concerns about rigidity of school structure (SS), while Sharon perceived that as a major obstacle for integrating CRP into standards-based mathematics. The PD supported Sharon's competencies in redressing bias (RB) as she shifted from deficit-based mindset to beliefs in her students' success with proper teaching.

Conclusion

The objective of this study was to develop teachers' cultural competencies and deepen their understanding of CRMP as they co-designed culturally relevant mathematics activities with researchers in a year-long PD. In earlier stages of PD, teachers showed understanding of students' cultural background and experiences, but were uncertain how to integrate CRP into mathematics curriculum. Early co-designed activities lacked connections between CRP and mathematics content, and teachers' dependence on researchers to make this connection was frequent. Over time, the influence of the co-designing process became evident. Teachers showed a deeper understanding of their students' cultures and how to integrate CRP into mathematics activities. They also started to pay more attention to developing their own cultural lens and focused less on constraints from school structures.

This study explored a new approach to PD by co-designing and implementing culturally relevant activities into standards-based mathematics. Doing so has led to the development of teachers' cultural competencies, deeper understanding of CRMP and their students' cultures, stronger agency, and ability to integrate culturally responsive pedagogy into their mathematics curriculum.

References

- Brown, T. (2008) Design thinking. *Harvard Business Review*, 86 (6), 85–92.
- Edwards, T. & Parada, H. (2022) Black youth disengaging from Ontario's educational system: Grounded theory of their educational experiences. (pp. 118–137) In K. Tilleczeck & D. MacDonald (eds), *Youth, Education and Wellbeing in the Americas*. Routledge.
- Heiner, C. (2018) 'A robotics experience for all the students in an elementary school'. In SIGCSE'18: *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*. Association for Computing Machinery, 729-734.
- Ladson-Billings, G. (1995) Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32 (3), 465-491. <https://doi.org/10.2307/1163320>
- Ladson-Billings, G. (2000) Fighting for our lives: Preparing teachers to teach African American students. *Journal of Teacher Education*, 51 (3), 206–214.
- Mark, S. L. & Id-Deen, L. (2022) Examining pre-service mathematics and science teachers' plans to implement culturally relevant pedagogy. *Educational Action Research*, 30 (5), 725-746.
- Matthews, L. E., Jones, S. M. & Parker, Y. A. (2022) *Engaging in culturally relevant mathematics tasks*. Corwin.
- Muniz, J. (2020) *Culturally responsive teaching: A reflection guide*. New America.
- New York State Education Department (NYSED) (2018) *Culturally responsive-sustaining education framework*. <https://www.nysed.gov/crs/framework>
- Putwain, D. W., Pekrun, R., Nicholson, L. J., Symes, W., Becker, S. & Marsh, H. W. (2018) Control-value appraisals, enjoyment, and boredom in mathematics: A longitudinal latent interaction analysis. *American Educational Research Journal*, 55 (6), 1339-1368.
- Rinke, C. R., Gladstone-Brown, W., Kinlaw, C. R. & Cappiello, J. (2016) Characterizing STEM teacher education: Affordances and constraints of explicit STEM preparation for elementary teachers. *School Science and Mathematics*, 116 (6), 300-309.
- Summerville, J. & Reid-Griffin, A. (2008) Technology integration and instructional design. *TechTrends*, 52 (5), 45-51.
- Thanheiser, E. & Koestler, C. (2021) If the world were a village: Learning mathematics while learning about the world'. *Mathematics Teacher Educator*, 9 (3), 202-228.
- Tilleczeck, K. & MacDonald, D. (2022) (eds) *Youth, Education and Wellbeing in the Americas*. Routledge.

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