CULTIVATING MATHEMATICAL PROFICIENCIES AND IDENTITIES THROUGH CULTURALLY AND COMMUNITY INSPIRED ACTIVITIES

CULTIVANDO PROFICIÊNCIAS MATEMÁTICAS E IDENTIDADES ATRAVÉS DE ATIVIDADES INSPIRADAS NA CULTURA E NA COMUNIDADE

CULTIVANDO COMPETENCIAS E IDENTIDADES MATEMÁTICAS A TRAVÉS DE ACTIVIDADES INSPIRADAS EN LA CULTURA Y LA COMUNIDAD

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ABSTRACT

Utilizing culturally-conscious teaching promotes instruction that values the cultural knowledge and experiences of ethnically diverse students. This qualitative study centers culturally responsive teaching (Gay, 2002) and community cultural wealth (Yosso, 2005) to contextualize mathematics learning for an after-school tutoring program in North Minneapolis, Prepare2Nspire. The aim of this research was to use a community-based participatory action research approach to: 1) explore the culture wealth of North Minneapolis, 2) create culturally responsive mathematics activities for Prepare2Nspire. Two activities were developed to center community assets and youth empowerment. The goal of these activities was to strengthen community, curriculum, and classrooms by intentionally connecting students’ multidimensional identities with mathematical learning. Specially, Muhammad’s (2020) culturally and historically responsive literacy framework was adapted using a mathematical lens to: 1) Create tasks that build mathematical proficiencies and 2) Create tasks that cultivate mathematical identities. The emphasis on participatory, community-based, and action-oriented practices in this study encouraged the disruption of deficit-based assumptions of communities while also creating joy-filled learning opportunities for Prepare2Nspire attendees.

Keywords: culturally responsive teaching, math learning, Prepare2Nspire.

RESUMO

Utilizar o ensino culturalmente consciente promove a instrução que valoriza o conhecimento cultural e as experiências de estudantes etnicamente diversos. Este estudo qualitativo centra o ensino culturalmente responsivo (Gay, 2002) e a riqueza cultural da comunidade (Yosso, 2005) para contextualizar a aprendizagem da matemática para um programa de tutoria extracurricular em North Minneapolis, Prepare2Nspire. O objetivo desta pesquisa foi usar
uma abordagem de pesquisa-ação participativa baseada na comunidade para: 1) explorar a riqueza cultural de North Minneapolis, 2) criar atividades matemáticas culturalmente responsivas para o Prepare2Nspire. Duas atividades foram desenvolvidas para centralizar os bens da comunidade e o empoderamento juvenil. O objetivo dessas atividades era fortalecer a comunidade, o currículo e as salas de aula, conectando intencionalmente as identidades multidimensionais dos alunos com o aprendizado matemático. Especialmente, a estrutura de alfabetização cultural e historicamente responsiva de Muhammad (2020) foi adaptada usando uma lente matemática para: 1) Criar tarefas que desenvolvam proficiências matemáticas e 2) Criar tarefas que cultivem identidades matemáticas. A ênfase nas práticas participativas, baseadas na comunidade e orientadas para a ação neste estudo encorajou a ruptura das suposições baseadas no déficit das comunidades, ao mesmo tempo em que criou oportunidades de aprendizado cheias de alegria para os participantes do Prepare2Nspire.


RESUMEN

El uso de la enseñanza culturalmente consciente promueve la instrucción que valora el conocimiento cultural y las experiencias de estudiantes étnicamente diversos. Este estudio cualitativo se centra en la enseñanza culturalmente sensible (Gay, 2002) y la riqueza cultural de la comunidad (Yosso, 2005) para contextualizar el aprendizaje de las matemáticas para un programa de tutoría extracurricular en el norte de Minneapolis, Prepare2Nspire. El objetivo de esta investigación fue utilizar un enfoque de investigación de acción participativa basada en la comunidad para: 1) explorar la riqueza cultural del norte de Minneapolis, 2) crear actividades matemáticas culturalmente receptivas para Prepare2Nspire. Se desarrollaron dos actividades para centrar los activos comunitarios y el empoderamiento de los jóvenes. El objetivo de estas actividades era fortalecer la comunidad, el currículo y las aulas conectando intencionalmente las identidades multidimensionales de los estudiantes con el aprendizaje matemático. Especialmente, el marco de alfabetización cultural e históricamente receptivo de Muhammad (2020) se adaptó utilizando una lente matemática para: 1) Crear tareas que desarrollen competencias matemáticas y 2) Crear tareas que cultiven identidades matemáticas. El énfasis en las prácticas participativas, basadas en la comunidad y orientadas a la acción en este estudio alentó la interrupción de las suposiciones basadas en el déficit de las comunidades y al mismo tiempo creó oportunidades de aprendizaje llenas de alegria para los asistentes de Prepare2Nspire.

Palabras clave: enseñanza culturalmente sensible. aprendizaje de matemáticas. Prepare2Nspire.

Introduction

Utilizing culturally-conscious mathematics teaching practices promotes instruction that values the experiences of ethnically diverse students while also making learning more situated, contextualized, and interactive (Bonner & Adams, 2012; NCTM, 2000; Razfar, 2012). Specifically, re-centering mathematics education around culture changes the image of math from one that is rigid, traditional, and oppressive to one that is transformative and inclusive (Nasir & de Royston, 2013). This study aimed to contextualize mathematics teaching and learning by highlighting a community filled with history and culture. North Minneapolis is an urban community not always seen through an asset-based lens because of high crime rates and a large percentage of residents living below the poverty line (Mannix & Hargarten, 2011). In order to address these shortfalls, a number of individuals and organizations are doing transformative work to change the narrative from a community filled with deficits to a community full of assets (Du, 2022; Duxter, 2022a; Duxter, 2022b). Re-framing the lens from deficit-based to asset-
based is not meant to ignore the social issues occurring within the community, but rather highlight resources in North Minneapolis and find ways to utilize those resources to create social change.

This qualitative study centered culturally responsive teaching (Gay, 2002) and community cultural wealth (Yosso, 2005) to contextualize mathematics learning for an after-school tutoring program in North Minneapolis, Prepare2Npsire. The mathematics activities created for this study will contribute to literature surrounding asset-based and culturally-responsive approaches to mathematics teaching by centering mathematical proficiency and identity development. This study will address the following research questions:

1. How can asset-based community knowledge inspire culturally responsive mathematics activities?
2. In what ways can culturally responsive mathematics activities cultivate mathematical proficiency and mathematical identity?

Research Motivation

Prepare2Nspire (P2N), a weekly after-school mathematics tutoring and mentoring program, recently celebrated its tenth year of serving the North Minneapolis community. P2N tutoring sessions are held at The University of Minnesota’s Robert J. Jones’ Urban Research and Outreach – Engagement Center (UROC) in North Minneapolis where a majority of P2N participants reside or attend school. P2N not only acts as an extracurricular outlet for in-school mathematics learning but also provides students of color social support from adult mentors. Within the P2N program, participants are divided into learning communities. Typically, these communities are created by assigning four to six eighth grade students and three to four eleventh grade students to one undergraduate mentor (mentor + tutor). This is a layered, near-peer framework where the undergraduates model tutoring and mentoring for the high school students who in turn mentor and tutor the middle school students. The learning communities collaborate on homework assignments and test preparation as well as share time and space to build relationships.

During this time, we (the authors) held a number of roles, including researchers, educators, and mentors. These experiences have given us first-hand knowledge of P2N’s strengths as well as the educational and cultural gaps. One key asset of the program that remains consistent is the emphasis on relationship building and intentional collaboration. Students feel supported both socially and academically and tutors gain skills that they can apply in their next positions after graduating from the university (Covington Clarkson et al., 2023). There is no denying the impact P2N has on those directly involved as well as the North Minneapolis community at large.

In order to continue this profound legacy, actions were initiated to evolve the program into a space that intentionally links mathematical learning and students’ cultural identities. When reflecting on the next logical steps, we wanted to explore the role of mathematics materials used in P2N. Typically, students bring homework assignments from school and receive assistance from undergraduate tutors. There are weeks, however, that students come to P2N without any assignments due to testing schedules or school vacations. In order to keep students engaged, we frequently photocopy practice problems from math textbooks. This is a convenient solution; however, this is also a limitation and we believe there are better options for supplemental materials that are directly catered to the cultural identities of P2N participants.

Theoretical Framework

Geneva Gay (2002) defined culturally responsive teaching as “using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively” (p. 106). An example of a culturally responsive approach is Gholdy Muhammad’s (2020, 2023) framework for culturally and historically responsive literacy. Muhammad’s framing includes five
distinct learning pursuits – identity development, skill development, intellectual development, criticality, and joy – in order to redesign the next generation of educators and respond to the limitations of traditional curricula (see Figure 1). The goal of this framework and associated learning pursuits is to “cultivate the genius” that lies within students, which “calls for reaching back into students’ histories and deeply knowing them and their ancestries to teach in ways that raise, grow, and develop their existing genius” (Muhammad, 2020, p. 13).

Figure 1: Historically Responsive Literacy (HRL) Framework, Muhammad (2020)

![HRL Framework Diagram]

Although the framework centers literacy, Muhammad notes that these five learning pursuits can be used and layered with other content areas, including mathematics. The conceptual framework developed for
this study views Muhammad’s learning pursuits through a mathematical lens. Specifically, adaptations were considered with two key goals in mind: 1) Creating tasks that build mathematical proficiencies and 2) Creating tasks that cultivate mathematical identities (see Figure 2).

Mathematical Proficiency

To adapt Muhammad’s framework for mathematics education research, the National Council of Research’s (2001) strands of mathematical proficiency were considered in relation to skill development. These strands included procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently, and appropriately), productive deposition (a habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy), conceptual understanding (comprehension of mathematical concepts, operations, and relations), strategic competence (the ability to formulate, represent, and solve mathematical problems), and adaptive reasoning (the capacity for logical through, reflection, explanation, and justification) (Aguirre et al., 2013; Thames & Ball, 2013). Developing mathematical skills does not depend on these strands as individual indicators but rather the combination of the five. Ideally, the developed community-inspired tasks will engage students in all strands to advance and amplify mathematical skills and literacy.

Mathematical Identity

Identity is an actively shifting contributor to mathematical persistence and learning due to one’s sense of connection and belonging (Nasir & Shah, 2011). Educators have a powerful role in influencing mathematical identity by strategically crafting their teaching practices to connect students’ lived experiences with mathematical learning. Additionally, Aguirre et al. (2013) included five equity-based practices to not only strengthen mathematical learning but also cultivate positive mathematical identities: 1) Going deep with mathematics, 2) leveraging multiple mathematical competencies, 3) affirming mathematics learners; 4) challenging spaces or marginality, and 5) drawing on multiple resources of knowledge. The combination of culturally relevant and equity-based practices gives educators intentional, although complex, ways to acknowledge mathematics as a subject full of opportunities for students to personally connect with.

It’s also important to note that the study’s conceptual framing of cultivating mathematical proficiency and mathematical identity does not ignore Muhammad’s original conceptualization of skills and identity development. Instead, both work together to creating mathematical learning opportunities that allow students to visualize themselves as capable of doing mathematics, thus validating and celebrating individual strengths while learning.

Research Methodology

This research study used a community-based participatory action research approach to: 1) explore the culture wealth of North Minneapolis and 2) create culturally responsive mathematics activities for Prepare2Nspire. This route was chosen because of its participatory nature which emphasizes doing research with others instead of doing research on others. Study participants are true co-researchers and communicate as equals, actively contributing to the research process (Maiter et al., 2008; Pope, 2020). The twelve participants of the study, referred to as the study’s research collective, had varying levels of connection with the North Minneapolis community and/or the Prepare2Nspire program (e. g. mothers of previous P2N students, a UROC employee, a former P2N tutor, two youth researchers and current North Minneapolis residents, and five K-12 students attending the P2N program). This is important to this research study because although we are the lead researcher, we are not the only individuals who influences P2N students’ learning experiences. Therefore, we included as many voices as possible to draw on a wide range of knowledges and identities.
In order to create culturally responsive and community inspired mathematics activities, ethnographic practices were included to better understand the social and cultural underpinnings of the North Minneapolis community. For this study, qualitative methods included visits to local businesses and landmarks, observations at community events, document analysis of community new sources, and contextual interviews to gain insight on how residents of North Minneapolis understand the complexities of their community. Next, mathematical content was combined with community knowledge to create collaborative and conversation-based activities. Specifically, each activity included a “Launch”, “Explore”, and “Summarize” portion to review mathematics content, push student thinking, facilitate discourse on mathematics content and community understanding, and allow students to consider their multi-dimensional identities. In addition to the overall structure of the activities, it was imperative to include pedagogical practices that cultivated mathematical skills and proficiencies as well as mathematical identities. Those practices are detailed in the findings section.

Findings/ Interpretation of Data

The following sections present two culturally responsive, community inspired mathematics activities that intentionally connect students' multidimensional identities with content-specific skills: 1) an asset-based coordinate plane and 2) a circle graph depicting the youth programs in North Minneapolis. In the following sections, the motivation for each activity is described, followed by the development process in terms of community influence and cultivation of mathematical proficiency and identity.

Activity 1: Asset-based Coordinate Plane

The purpose of the asset-based coordinate plane activity was to introduce young people, especially P2N students, to the beauty and brilliance engrained in North Minneapolis. Twenty community assets, mainly local institutions and citizens’ associations, were mapped onto a coordinate grid (see Figure 3). These assets were chosen because of their contribution to positive community development, potential opportunities for positive youth development, and relatability for P2N attendees. The included assets are color coordinated: 1) Blue assets represent museums and theaters, 2) Red assets represent university buildings, 3) Orange assets represented local businesses, 4) Green assets represent local parks, 5) Purple assets represent non-profit and/or social services organizations, and 6) Black assets represented other local institutions.

Figure 3: Asset-based Coordinate Plane
Cultivating Mathematical Proficiency

The goals of the asset-based coordinate plane activity were for P2N students to practice mathematical proficiencies surrounding plotting coordinate points, recognizing key features of a coordinate plane, calculating slope, and finding distance between two coordinate points. Throughout this activity, students will be able to practice conceptual understanding and procedural fluency (see Table 1).

<table>
<thead>
<tr>
<th>Tenet</th>
<th>Mathematical Benchmark</th>
<th>Activity Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual understanding</td>
<td>Graph proportional relationships, interpreting the unit rate as the constant of proportionality of the graph. Compare two different proportional relationships represented in different ways.</td>
<td>Students will discuss the connection between concepts of slope and proportional relationships.</td>
</tr>
<tr>
<td>Procedural fluency</td>
<td>Identify graphical properties of proportional relationships including slope. Know that the slope equals the rate of change and that the y-intercept is zero when the function represents a proportional relationship.</td>
<td>Students will plot points on the coordinate plane and calculate slope. Example questions: What is the coordinate point for UROC? What asset is at (-11, -6)? Pick two assets on the map. What is the slope between those points?</td>
</tr>
</tbody>
</table>

Cultivating Mathematical Identity

One equity-based practice incorporated into the asset-based coordinate plane activity was leveraging multiple mathematical competencies. This works toward cultivating mathematical identity by creating multiple entry points for all learners depending on their current understanding of coordinate planes. P2N learning communities included students from various grade levels, ranging from seventh grade to seniors in high school. It was key in the development process that the mathematical tasks were scaffolded so all learning levels were able to engage depending on their previous knowledge and willingness to collaborate with other students.

Additionally, the asset-based coordinate plane activity was strategically designed to connect previously learned mathematics topics with experiences within the North Minneapolis community and new learning benchmarks. P2N students will be able to draw on multiple resources of knowledge, mainly mathematical and community knowledge, to complete tasks. For instance, during the “Launch” portion of the activity, questions will allow students to share joyful stories about their experiences in the North Minneapolis (e.g. What different businesses, restaurants or activities have you been to in North Minneapolis?). Additionally, students will use previous mathematics knowledge (e.g. concepts of proportional relationships) as a bridge to promote new understanding (e.g. slope).

Activity 2: Youth Programs Circle Graphs

To highlight the number and variety of available youth programs in North Minneapolis, a pictorial representation of eleven categories of programs was created (see Figure 4). The purpose of this activity was to highlight youth-centered programs and career apprenticeship that are positive, affirming spaces in the community where young people can feel safe, love, and supported. This is a particularly important
outlet for positive youth development and potential shelter from increasing gun violence incidences in North Minneapolis.

**Figure 4: Youth Programs Circle Graph**

Cultivating Mathematical Proficiency

The goal of the youth programs circle graph was for P2N students to practice mathematical proficiencies surrounding percentages, finding total number of programs in each category, and using multiple strategies to compare and contrast different program genres. Throughout this activity, students will be able to practice conceptual understanding, procedural fluency, and strategic competence (see Table 2).

<table>
<thead>
<tr>
<th>Tenet</th>
<th>Mathematical Benchmark</th>
<th>Activity Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual understanding</td>
<td>Demonstrate an understanding of the proportional relationship between the diameter and circumference of a circle and that the unit rate (constant of proportionality) is π.</td>
<td>Students will discuss the connection between concepts of pi, circles, and percentages.</td>
</tr>
</tbody>
</table>
| Procedural fluency  | Solve problems involving percentages as a rate per 100, such as finding the part, given a whole and the percentage and find the percentage given the part and the whole. | Students will find the total number of programs in each category and compare/contrast.  
  **Example questions:** What category has the most programs? How do you know? |
| Strategic competence | Create an infographic about a data set, organizing and presenting the data in appropriate ways, including in tables, circle graphs and histograms and incorporating any other relevant information that helps to tell a story about the data | Students will collaborate with one another to discuss different ways to visually represent youth programs in North Minneapolis instead of a circle graph.  
  **Example question:** I did this as a circle graph. How else could you represent this data? |

**Table 2: Mathematical Proficiencies for the Youth Programs Circle Graph**
Cultivating Mathematical Identity

One equity-based practice incorporated into the youth programs circle graph activity was challenging spaces of marginality. This works toward cultivating mathematical identity by encouraging student-to-student interaction and various ways for participation. The goal behind creating a conversation-based mathematics activity was to promote higher-level thinking skills by collaborating with peers and boosting students’ self-confidence in their ability to do math.

Similar to the asset-based coordinate plane, the youth programs circle graph drew on multiple resources knowledge to cultivate mathematical identity. This included making intentional connections to multiple knowledge resources to support mathematical learning. For instance, during the “Launch” section of the circle graph activity, questions will be asked to examine their knowledge about and interest in youth programs (e.g. What different youth programs or activities have you participated in North Minneapolis? What did you enjoy? What kind of activities would you like to do? Out of all the categories, which one would you want to do more of?). These engaging conversations will allow small groups to celebrate individual strengths and passions while also validating the perspective that North Minneapolis is a warm and welcoming community where youth are able to enhance their talents and connect those talents to future career opportunities.

Discussion and Future Directions

According to Nasir (2002), identity development involves identifying as a member of a community of practice and negotiating ownership and agency within those social structures. This combination of identification and negotiation turns the learning process into an empowering and situated experience for students, thus contributing to their understanding of self in various settings. An important aspect of culturally relevant education is creating opportunities for students to learn about themselves and their intersectional identities. The overarching goal of combining community assets and mathematical learning in the two activities highlighted in this study is to: 1) Engage students academically by valuing their situated knowledge and 2) Cultivate their identity development by making math an approachable subject that affirms their multidimensional ways of knowing. In addition to promoting mathematical proficiency and identity, the collaborative activities were created to validate the narrative that North Minneapolis has assets and resources to offer community members, especially to youth.

The next research stage will document P2N students as they engage with the two activities. Observational field notes will record instances of mathematical discourse, interactions between peers, critical conversations, connections between activities and typical schoolwork, and productivity. as well as create activities that address all tenets of the conceptual framework. In addition, student observations will serve as feedback for the creation of new activities. For this research, the two culturally responsive mathematics activities largely represented the procedural fluency and conceptual understanding strand of mathematical proficiency (National Research Council, 2001). Additional activities will better address the remaining strands (productive deposition, strategic competence, and adaptive reasoning). Future work will continue to provide examples of culturally responsive mathematics teaching in order to affirm the talents, beauty, and brilliance students naturally possess.

References


