




Enacting Inclusive Mathematics Teaching and Learning Using Biography-Driven Instruction

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Abstract

As schools become increasingly diverse, there is an increasing need for examples of classroom practices that create inclusive teaching and learning environments. Many research studies found that gaining knowledge of student home life and using it to bridge learning and home supports access and equity. Many scholars have called for exemplars of activities that connect students' in-school and out-of-school cultural activities. This paper provides an example that may be used in teacher education and K–12 classrooms to bridge out-of-school and in-school activities. In this paper, we discuss the enactment of biography-driven instruction, specifically how cultural biographies can be used to create inclusive mathematics teaching and learning.

Keywords: *mathematics, inclusive teaching, biography-driven instruction*

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Introduction

The goal of this paper is to provide examples of an instructional approach that leverages technology to blend school, home, and community borders to provide access and equity in mathematics instruction. We discuss how educators may use photobiographies not only to enact an inclusive teaching and learning environment but also to provide an example of photo-ready activities for K–12 classrooms and teacher education settings. The report is written based on literature and my 10-year experience of using photobiographies in mathematics education.

Background

Aguirre and Zavala (2013) expressed that “there is a need for pedagogical tools that help teachers develop essential pedagogical content knowledge and practices to meet the mathematical education needs of a growing culturally and linguistically diverse student population” (p. 163). As schools become increasingly diverse, the need for pedagogies that use cultural capital is also increasing (Tileston & Darling, 2008; Wachira & Mburu, 2019). Designing lessons and a classroom environment that meets the needs of all students requires the

teacher to be intentional about knowing and using the students' cultural, family, intellectual, and personal experiences as a resource for instruction (Neel, 2005; Young, 2010). Learning about students' out-of-school experiences and making connections with mathematics instruction is a challenge (Tanase, 2021). A student teacher who may only have one semester of student teaching needs to make connections with their students and understand their out-of-school experience within a short time while facing other challenges typical to student teaching experiences (Ramsay-Jordan, 2021). A new educator or an educator with a new group of students also needs to learn about the cultural norms and interests of individual students and student groups. The challenges that educators face may stem from teacher education. Morrison, Thompson, and Glazier (2022) encouraged teacher educators to question, "do we practice what we teach?" and advocated for the scholarship that exemplifies "best practices in culturally responsive teacher education" (p. 26). The objective of this paper is to respond to the calls by Morrison and colleagues, Ukpokodu (2011), and Harding-Dekam (2014) to provide exemplars of activities that bridge students' in-school and out-of-school cultural activities.

Inclusive Teaching and Learning in Mathematics

In their 2014 position statement, the National Council of Teachers of Mathematics wrote that creating and sustaining a culture of access and equity requires "being responsive to students' backgrounds, experiences, cultural perspectives, traditions, and knowledge" (para. 2). A meta-synthesis of research, published between 1994 and 2016, by Thomas and Berry (2019) identified pedagogies for access and equity. They found that seeking knowledge about learners, their communities, and home life and using this knowledge in teaching and learning promotes access and equity. Thomas and Berry also reported that cultural competency and high-quality instruction that connects to cultural artifacts so students can make personal connections to the content is productive. In another meta-synthesis of 35 studies published between 1993 and 2018, Abdulrahim and Orosco (2020) reached conclusions similar to those by Thomas and Berry. Abdulrahim and Orosco further highlighted the importance of teachers reflecting on their practices and values and recognizing and addressing racial disparities.

More recent studies echo these characteristics that emerged in the meta-syntheses. Herrera (2022) used the framework of biography-driven instruction to recommend that teachers first be participant observers of students' biographies, and then use students' funds of knowledge from home, their community assets, and school assets to guide instructional decisions. Yu's (2022) study (with 175 students) found that not only does culturally relevant pedagogy improve student achievement, but it improves students' attitudes toward mathematics. Thus, empirical studies show that pedagogies that provide access and equity use student biographies as assets to support both student achievement and the development of mathematics identities.

Photobiographies

Khazraee and Novak (2018) describe photobiography as a practice and genre in which one takes photos, arranges them, and tells a story about their life. A photobiography may be used to tell a person's story about their history, beliefs, understandings, experiences, and values (Hatten et al., 2013). With photography, the narrator has control of how they enact the self and invite people to reflect on that self-enacted identity (Senft & Baym, 2015).

A *cultural photobiography* is a narrative in which photos are embedded to convey cultural meanings. While each photo conveys meaning, the relationship between photos may tell teachers a deeper meaning that the students may not make explicit.

A *cultural math photobiography* tells a cultural story about the students, their families, and communities from a math perspective by either pointing to the mathematics in the cultural artifacts or mathematizing experiences to make more explicit the mathematics that may be implicit. Such photobiographies are useful for not only learning about diverse experiences but also for identifying ways of intervention (Fellus, 2019).

Ultimately, biography-driven instruction is academically rigorous, research-driven, and practically tested as an effective method for culturally and linguistically diverse classrooms (Murry et al., 2020, p. 108)

Steps for Enacting Mathematics Biography-Driven Instruction

1. Writing Mathematical Stories

A mathematical story should balance elements of a story and center key and developmentally appropriate mathematical concepts. Writing stories that center on both story elements and mathematical concepts is a challenge for many students. Mathematical stories should have the typical story elements of character, plot, and theme (Drake et al., 2001; Kaasila, 2007). For stories to be a rich classroom resource for serving the diverse needs of students, students should write about characters that are either real or represent family and community members. The plot should be relatable to the students' lived experiences. As students think about the plot of their story, they should describe events and their meanings.

While many students came into this project having had many opportunities to write stories, very few have had significant opportunities to summarize mathematics concepts or to write about math. As such, writing good stories that connect their experiences to math is initially a challenge for students. Students I have worked with begin by writing stories that mirror textbook word problems without much relevance to their identities and typically opt for math that is not developmentally challenging for them. Given these issues, an effective starting point is providing a mathematical concept, asking students to identify key parts of the concept, and then asking students to write a story about it with clear characters and a plot. In our practice, we have found that requiring (a) concept definition; (b) a step-by-step summary of the mathematical process; and (c) a solved example create a more accessible template for students when summarizing key parts of mathematical concepts. The concept summary could be summarized as in Table 1.

Writing stories for a given math concept is, perhaps, as important as mathematizing stories about one's experience. If a student finds cooking with family members to be an important story of their life, they should be provided opportunities to write about it and to focus on the math concepts that are in—or can be related to—that practice. Changing the starting point from math to the story helps students practice and prepares them to write math stories with cultural and familial referents.

2. Assigning a Photobiography Project

Instructions given to students for a cultural math photobiography project should require multiple photos of different activities and artifacts that are meaningful to the student. The following student instructions help set the expectations for photobiographies:

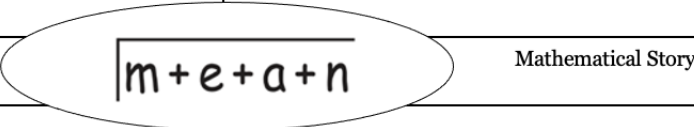
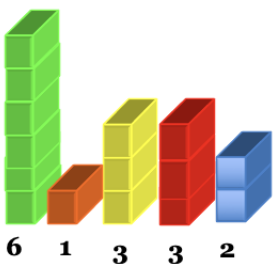

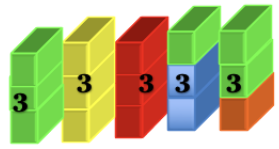
1. Collect photos that tell a story about things and experiences that are meaningful to you or your family. The photos should be about where you are from, your traditions, beliefs, values, challenges, and hopes. You may supplement your photos with videos or audio recordings.
2. Choose your grade-level math concept that relates to your photobiography. This could be a concept that is on, behind, or related to what's in your photos.
3. Do a summary of your math concept that includes a definition, process, and example.
4. Write a mathematical story based on your photobiography. Your story should have characters and a plot that are relatable to you.
5. Pose a mathematical problem related to your math concept and story. Solve the problem in your story.
6. Submit your photobiography to your teacher.

- Present your photobiography to the class (or the teacher) in an engaging way that leaves a lasting emotional impression.

Some students may find it risky to tell their cultural stories with photobiographies. If the class and school community are not affirming diversity, sharing cultural stories may lead to bullying and other injustices. Educators need to preview photobiographies, and upon student request—or if teachers find it necessary—some students may share parts of the assignment with only the teacher.

The photobiography instructions (above) allow students to decide on the math concepts as they see them through their cultural photobiographies. This freedom to identify the math concepts in the cultural artifacts is empowering and has the potential for surprising and rich cultural and mathematical explorations. A student might find an artifact in their home that leads to cultural and math learning that they did not anticipate. Photobiographies need to allow for this kind of learning.

Table 1. *Mathematical Story Writing Practice*

Definition	Process
<ul style="list-style-type: none"> a fair share or balance point for data 	<ol style="list-style-type: none"> Add all the numbers to find the sum. Divide the sum by how many numbers there are.
<p>Example</p>	<p style="text-align: center;">  </p>
<p>Data</p>  <p style="text-align: center;">6 1 3 3 2</p> <p>Calculating the mean</p>  <p>Add: $6 + 1 + 3 + 3 + 2 = 15$</p> <p>Divide: $15 \div 5 = 3$</p>  <p>Mean = 3</p> <p style="text-align: right;"><i>Write a story about how your family or community members may use Mean as a problem-solving tool. Make sure your characters, plot, and theme are meaningful.</i></p>	

3. Enacting Biography-Driven Instruction

Enacting biography-driven instruction can be a part of different pedagogies that focus on important mathematics, communicate the value of student identities, model shared power between students and educators, and aim for equitable class participation. As such, the photobiographies continue to be a resource for biography-driven instruction for a unit or other long-term plans. With photobiographies, educators integrate student stories and experiences in the mathematics curriculum in ways that consider student identities and where their everyday mathematics takes place. Naturally, an educator's cultural experience may affect the preference and ease with which they integrate student experiences in mathematics instruction.

Biography-driven instruction that prioritizes access and equity, in our experience, relies on written records of how each student's biography is used. Table 2 is an example of how an educator may set up a record to plan and track the use of biographies. Educators may set up units or topics for their long-term planning, such as a year or a semester plan, and fill the table with activities to identify the students whose biographies have been incorporated.

A written record, such as Table 2, gives educators information on who is included in the curriculum and by how much—and who still needs to be included. It may also inform educators on how often they include students' biographies in their curriculum. Records like these support educators' intentionality in creating inclusive learning environments.

Table 2. *Tracking the Integration of Biographies and Math Curriculum*

Unit	Activity	Rationale/Description	Connection With Student Biography
Statistics	<ul style="list-style-type: none"> Study numerical data on effects of cross training on speed. Conduct a study on the speed of athletes who cross train versus those who do not. 	Family members and student athletes are interested in building speed.	Diane, Jane, Alex (Cross country) Jim, Bob, Janet, Mary (Soccer) Cynthia, Moses, Caleb (Football)
Expressions and Equations	<ul style="list-style-type: none"> Compare minimum wage with a living wage for a community. 	Understand differences in family activities.	Lynn (They aspire to open their own business.) Jim (Family members are social justice activists.)

4. Reflecting on and Examining Teacher Practices

Enacting inclusive mathematics instruction requires a continuous process of examining educators' biases and cultural competence (Van de Walle et al., 2019). Educators should do a self-assessment of which cultures and identities they are more at ease with incorporating into the curriculum and learn more about those that were relatively less familiar and more challenging. Reflections should also focus on students' academic and social achievements or progress. As important as it is to track which student inventories have been used in the curriculum, it is equally, or more important, to examine how the stories from different groups have been used. Cultural math photobiographies should not just be about sharing cultural stories; they must be used to empower student identities.

Table 2 is only a starting point for keeping a teacher accountable for identifying whose cultural photobiographies have been used in the curriculum and in what ways. Educators also need to reflect on whether the photobiography-based activities and classroom examples are putting some cultures, socioeconomic statuses, and other social classes in subordinate positions. The goal is to assess how the teachers' integration of photobiographies and curriculum has built diversity-affirming communities inside and outside of the schools.

Mathematics Teacher Education Example

In this section, we will share a recommended sequence and activities for mathematics teacher education for developing espoused and practical readiness for enacting biography-driven instruction. The recommendations evolved from critical analyses and reflections of records of teaching including teacher candidates' artifacts over a period of several years. Although developed from work with teacher candidates, the sequence and activities can be used in a professional development setting. As may be noticed, this sequence and activities situate biography-driven instruction within a family of theories, perspectives, and practices that promote equity in mathematics teaching.

Activation Phase

In this phase, the mathematics teacher educator acknowledges that the teacher candidates bring to the mathematics education courses a prior understanding of culturally responsive teaching praxis, multicultural education, and inclusive education. The prior knowledge may have been developed through their lived experiences, prior courses (such as educational foundational courses), and the college's general education curriculum. The activation phase in our classes can be summarized in three steps:

- Step 1: Activate individual student's knowledge.
- Step 2: Discuss one's understanding with individual group members and whole-class discussions.
- Step 3: Submit a written after-discussion response in the Learning Management System.

The teacher educators use discussion questions that bring out information pertinent to enacting biography-driven instruction for inclusive teaching and learning. Before discussions, each student activates their prior knowledge by responding to the discussion question, which may be summarized as in Table 1. The group discussions provide rich information to the teacher educator as group members explain and defend their views. Additional prompts may ask students to compare the concepts and to decide which of the groups' observed classroom examples best exemplify each concept. The after-discussion written response provides information on what the candidates choose as key information. To encourage students to move beyond what they wrote during class discussions, we find it necessary to not use the class discussion questions, but rather to rephrase the questions and write new ones that extend ideas raised during discussions.

Table 3. *Activation Chart and Discussion Guide*

	Definition	Key Aspects	Observed Classroom Example
Multicultural Education			
Inclusive Education			
Culturally Responsive Pedagogy			

Connection Phase

The activities for this phase serve a goal of connecting the known and the unknown, such as prior understanding, mentor teachers' perspectives, and readings on inclusive mathematics teaching. The goals are to support teacher candidates' understanding of inclusive mathematics teaching and to develop critical reflective habits of teaching practices and mathematics curricula. This phase uses the student responses from the activation stage as a formative assessment to identify assets for future teaching and learning.

Readings, such as Morrison et al. (2008), bridge the discussions of effective culturally responsive teaching praxis with biography-driven instruction. One focus at this phase should be critically thinking about one's socialization and cultural schemas, that our lives and learning are storied. Candidates are given opportunities to reflect on whose stories—and therefore lives—are centered in mathematics teaching. One activity to help candidates' critical thinking about students involves interviews with mentor teachers using questions that may include:

1. How well does your mathematics curriculum use stories to teach math concepts?
2. How do the stories in the math curriculum relate to your students' backgrounds?
3. Please give examples of when you used your life experience to teach or tell a story during your math lessons.
4. What do you do to learn about your students' background and non-school experiences?
5. Do you incorporate students' stories and experiences in your teaching? If so, how?

Activities, such as these candidate interviews with mentor teachers, are opportunities for teacher candidates to critically reflect on their socialization through schools, both as students and teacher candidates. The hope of this phase is for teacher candidates to begin to see that learning and then enacting inclusive teaching requires purposeful planning to take account of student biographies.

Practice Phase

Just as teachers practice doing the math they teach, this phase creates an opportunity for teacher candidates to connect mathematics and their own biographies. We use the activity reported by Neel (2005) on writing a story about a cultural artifact from a mathematical perspective. Similar to the photobiography project discussed earlier, teacher candidates choose a meaningful artifact from their culture and report it from a mathematical perspective. These instructions guide candidates' work:

1. Choose a cultural artifact that is meaningful to you or your family.
2. Describe the artifact using pictures or bring the artifact to class.
3. Explain why you selected the artifact.
4. Write a story or poem about your artifact. Your writing should leave a lasting emotional and affective impression.
5. Create a math project or write a mathematical problem based on your chosen artifact, at a skill level appropriate for your identified grade.
6. Present your work to the whole class.
7. Write a reflection on how this project exemplifies a tool for inclusive teaching and how it may be adapted for a K–12 setting.

Biography-Driven Lesson Planning

During clinical experiences, teacher candidates are expected to assist mentor teachers with tasks that include facilitating small group work or providing one-on-one support to students. Interactions with students are opportunities for candidates to get to know the biographies of the students. Candidates are encouraged to value both social and academic interactions as they assist in small groups. After weeks of clinical experiences and interactions with students, candidates are assigned to plan a lesson for their clinical experience class. The student background section of the lesson plan requires students to include the general characteristics of the class and to include students' biographies that will be centered in the lesson. The instructional procedure assessment includes how well the student biographies have been integrated with the mathematics lesson.

Affirmation Phase

We have noticed that many teacher candidates do not feel confident in their abilities to enact inclusive mathematics teaching that centers on biographies of people different from theirs. Affirmation is critical in building candidates' self-efficacy. Inclusive teaching is a learning journey that is supported by affirming candidates' prior knowledge and new understandings. Teacher educators can integrate affirmation in all the activities at different phases. We also find candidates' reflections at the end of the semester about their learning of inclusive teaching an important part of their journey. We use these prompts to guide their end-of-semester presentations:

1. What I have learned.
2. How I learned it.
3. How I will apply it.
4. How I will continue learning about it.

Conclusion

Cultural photobiographies are rich resources for inclusive mathematics teaching and learning. They affirm students' identities as doers of mathematics and tell students' cultural stories in ways authentic to the storytellers. Using the steps discussed in this paper for using photobiographies, educators and teacher educators can support mathematics learning for all. Students can see the different mathematics topics as part of their communities in and out of school. These considerations also support teachers in keeping themselves accountable in their efforts to create equitable access to mathematics learning.

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