EXAMINING EQUITY-ORIENTED INSTRUCTIONAL PRACTICES IN A DEVELOPMENTAL ALGEBRA PROJECT TO SUPPORT UNDERGRADUATE STUDENTS' EQUITY OUTCOMES

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The Thinking With Algebra (TWA) project, which consists of a developmental algebra curriculum and supporting professional development, has been integrated into diverse algebra courses to support undergraduate students' success in college algebra (Feikes et al., 2024). This paper examines the equity-oriented instructional practices integrated into TWA to support strengthened equity outcomes among students. This project draws on sociopolitical equity scholarship (Rubel, 2017), including a framework consisting of achievement, access, identity, and power (Gutiérrez, 2012). Instructor and student data indicate positive changes in student achievement and identity outcomes. Future directions include expanding the integration of equity-oriented instructional practices and investigation of student equity outcomes. Applying an equity lens to TWA is critical given the barriers students, particularly minoritized students, face in algebra.

Keywords: Equity, Inclusion, and Diversity; Instructional Activities and Practices; Undergraduate Education; Algebra and Algebraic Thinking.

Background

Ample evidence indicates a national crisis related to students successfully completing algebra coursework, which is extremely concerning given that algebra serves as a gateway to higher level mathematics and science courses (Domina et al., 2015; Long et al., 2012), to postsecondary success at colleges and universities (Spielhagen, 2006), and to STEM degree pathways (Loewenberg, 2003). Despite efforts to improve the teaching and learning of algebra, many students are still struggling with the subject and are not persisting in their mathematics coursework (Greenes, 2008). Additionally, when students do not successfully pass algebra coursework, aspects of their mathematical identities are likely to be negatively impacted, such as developing negative attitudes and beliefs about mathematics. Even more concerning is the significant underrepresentation of minoritized students, including Black, Latinx, and low-income students, in the student population successfully completing algebra coursework (LaFave, 2019), attaining STEM degrees (Fry et al., 2021), and pursuing STEM careers (Fry et al., 2021).

This paper draws on sociopolitical mathematics education equity scholarship (Rubel, 2017), a framework within this literature consisting of four dimensions: achievement, access, identity, and power (Gutiérrez, 2012), and prior research by the authors (Oppland-Cordell et al., 2024) to examine how the instructional practices of the TWA project, which is funded by the National Science Foundation Improving Undergraduate STEM Education: Education and Human Resources (IUSE: HER; DUE 2021414), align with equity-oriented instructional practices appearing in this scholarship. The research questions are: (1) *How do TWA instructional practices align with equity-oriented instructional practices?* and (2) *How does students'*

participation in TWA impact their mathematical achievement and identity development? Such findings will expand knowledge about how to create equitable mathematics learning environments in developmental academic settings that support students' mathematical success.

Theoretical Framework

Gutiérrez's (2012) equity definition consists of four dimensions: access, achievement, identity, and power. Drawing on this definition, this project defines the four equity dimensions in relation to the design, instructional practices, and professional development components of TWA. Table 1 includes these definitions.

Table 1: TWA's Equity Dimension Definitions Adapted from Gutiérrez's (2012) Framework

Equity Dimension	Design, Instructional Practices, and Professional Development
Achievement	TWA supports students' strengthened mathematics achievement outcomes as measured by participation rates, persistence rates, and student self-perceptions of achievement.
Identity	TWA supports students' strengthened mathematics identity development, including how they co-construct this identity with their other identities. Measures include student self-perceptions and perceptions of how other view them as mathematics learners.
Access	TWA mandates professional development to support high quality mathematics instructors. Through group work and whole class discussions, TWA encourages a learning environment that supports student participation in and out of class.
Power	Through small group and whole class discussions, diverse voices and alternative notions of mathematics knowledge are embraced in the mathematics learning context.

While Gutiérrez's equity dimension framework provides guidance for defining equity for the TWA project, we also wanted to investigate how specific instructional practices integrated into TWA align with equity-oriented instructional practices appearing in emerging sociopolitical mathematics education equity scholarship. Drawing on Gutiérrez's (2007) equity research, Rubel (2017) identified and organized four "equity-directed instructional practices from four models of progressive pedagogy," of which three are highlighted here: standards-based mathematics instruction (SBMI), complex instruction (CI), and culturally relevant pedagogy (CRP) (p. 69). Rubel also highlighted a specific instructional practice from each model that collectively revealed how these pedagogies are interconnected and build upon one another: *SBMI*: teaching for understanding; *CI:* multidimensional participation; and *CRP*: connecting mathematics instruction to students' experiences. While the SBMI and CI examples strongly align with the access and achievement dimensions in Gutiérrez's work, the CRP example closely aligns with the identity and power dimensions (Rubel, 2017). This study draws on these specific examples to inspect overlap and growth opportunities for the equity-oriented instructional practices employed in TWA. In particular, this study explores how TWA currently teaches developmental mathematics in ways that contributes to strengthening students' conceptual understanding, supporting their multidimensional participation, connecting mathematics instruction to their experiences, and applying mathematics in critical ways to navigate their lives and worlds.

Methods

TWA Context and Participants

TWA is a developmental algebra curriculum that supports undergraduate instructors in teaching algebra in a way that conceptually and procedurally prepares students for success in college algebra (Feikes et al., 2021; Feikes et al., 2024). TWA also provides a faculty workshop to support college instructors with understanding and implementing the curriculum with undergraduate students. This study focuses on TWA implementation at a community college in Illinois designated as a Predominately Black Institution (PBI) and an emerging Hispanic Serving Institution (HSI) and a public university in Indiana designated as an HSI. Preliminary findings related to the achievement and identity dimensions are provided for student populations in both of these contexts, which reflect general student demographic data at the respective institutions.

Data Collection and Analysis

The authors created a collaborative inquiry community (Larrivee, 2000) to explore TWA instructional practices. A critical component of the data collection process included biweekly professional development meetings where the team discussed TWA instructional practices that aligned with Rubel's (2017) framework. Such discussions centered on central themes of the TWA curriculum (e.g., distributed practice) and TWA classroom organizational approaches (e.g., class discussions, small-group work) contained in the TWA instructor textbook: *Thinking with Algebra (TWA) Success in Algebra and Beyond* (Feikes et al., 2023).

We also provide preliminary findings on student outcomes related to aspects of the achievement and identity equity dimensions to provide evidence of TWA's positive impact on students. Such student outcomes were explored using mixed-methods, including quantitative and qualitative methods, which this project plans to expand on in the future by collecting and analyzing data related to all four equity dimensions. The quantitative data collected and analyzed included pre- and post-survey student responses that focused on mathematics self-efficacy (Bandura et al., 1999). For six instructors who used TWA and implemented equity-oriented instructional practices during the first year of the project in 2020, the quantitative and qualitative data collected and analyzed included survey and interview data, which revealed how instructors believed TWA impacted student identity development.

Preliminary Findings

Table 2 indicates how TWA instructional practices mapped onto Rubel's (2017) equity-directed instructional practice examples, which are organized within four pedagogical models.

Table 2: TWA Instructional Practices Aligning with Rubel's (2017) Equity Examples

Progressive Pedagogical Models (Rubel, 2017)	Questions Explored for TWA Related to Rubel's (2017) Examples	TWA Instructional Practices
Standards-based mathematics instruction (SBMI)	How does TWA teach students developmental mathematics in ways that supports their conceptual understanding?	* Curriculum design directly supports conceptual understanding * Curriculum integrates distributed practice * Students engage with the physical format of curricular materials
Complex instruction (CI)	How does TWA support students' multidimensional	* Integration of small-group work and whole class discussions in

	participation?	mathematics learning contexts * Students are encouraged to discuss personal understandings or misunderstandings, diverse solutions, and methods * Connect/build on prior math knowledge
Culturally relevant pedagogy (CRP)	How does TWA connect mathematics instruction to students' experiences?	* Building strong relationships with students * Embracing multiple solution strategies that reflect students' experiences and culture

Preliminary findings on achievement and identity student outcomes based on both quantitative and qualitative student and instructor data indicate positive changes in both of these dimensions. For example, statistical analysis of the mathematics self-efficacy survey data showed emerging confidence (n=39, p=.12) in students' ability to succeed in their next mathematics class with a small (d =.33) effect size. The authors plan to collect more data to test at a smaller, $\alpha = .05$, significance level. Feedback from instructors through interview and survey responses indicated that students are constructing strengthened mathematical identities (e.g., confidence) in relation to their engagement with the TWA curriculum.

Conclusion and Future Directions

Emerging mathematics education equity research supports applying broader sociopolitical equity definitions to mathematics education research because this theoretical lens can provide additional knowledge regarding how and why students and minoritized students attain mathematical success. This research addresses a gap in existing mathematics education scholarship by drawing on emerging equity research to identify equity-oriented instructional practices integrated into the TWA developmental mathematics curriculum that can serve to support strengthened equity outcomes among students, broadly defining such equity student outcomes using a sociopolitical equity framework, and providing evidence of improvements in student achievement and identity outcomes based on student and instructor data. Future directions include collecting additional quantitative and qualitative data to further investigate student experiences and outcomes related to the four equity dimensions, investigating such experiences and outcomes for minoritized learners, and integrating additional equity-oriented instructional practices that can support improving such experiences and outcomes. Examples of additional equity-oriented instructional practices include integrating culturally responsive and social justice-oriented materials into the TWA curriculum. Importantly, this project expands knowledge about the equity-directed instructional practices that can be integrated into mathematics learning contexts, including developmental settings, to support students' mathematical success.

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