ACCOMMODATION, INCLUSION, AND EXPANSION: THEORIZING EQUITABLE INSTRUCTION

Joy A. Oslund[1], Tasnim Alshuli[2], Hope Gerson[1], and Paul W. D. Yu[1]

[1]Grand Valley State University, [2]University of Arizona

This paper puts forth a model for expansive mathematics teaching for students with disabilities. We consider three lessons in which embodied mathematical curricula were used to support a blind student in collegiate mathematics courses. The goal of the lessons was to provide access and inclusion for the blind student as they worked to make sense of the mathematical concepts. What resulted were moments in which the student's conceptions and participation in their community of practice extended beyond what was expected, leading to expansive learning opportunities. We propose a model of embodied activity that goes beyond providing access and inclusion, striving for expansive notions of mathematical sensing and learning for all.

INTRODUCTION

Mathematics is often conceptualized as a visual discipline; therefore, education for students who are blind or have low vision (SBLVs) can be subpar. Responses to this problem often revolve around accommodations and assistive technology to provide access to visual information through auditory and tactile materials. While these adaptations make some math content more accessible, they are often inadequate, and students still miss visual information, such as work written or projected on the board (Bell & Silverman, 2019) and teachers' and classmates' gestures. This has not promoted equitable learning opportunities for SBLVs in math classes. Work on inclusion in mathematics classrooms has focused on providing inviting, collaborative spaces that meet many students' needs to promote equitable participation (e.g. Louie, 2017; Padilla & Tan, 2019). A tool often used to create inclusive spaces in classrooms is Universal Design for Learning (UDL) (CAST, 2024). UDL pays some attention to supporting SBLVs. Recommendations include providing alternative ways to perceive graphic information (e.g. descriptions, touch equivalents, and audio cues). However, we argue that these still assume starting with a mathematical curriculum designed for sighted students. UDL includes fostering collaboration but less is known about how collaboration around alternative means of perception might look and sound, or how teachers might support it. UDL also recommends cultivating multiple ways of knowing, including kinesthetic. However, it does not alter the assumption that math is a visual subject and that SBLVs must be accommodated to understand a curriculum that was designed for sighted students. Related research has begun to connect UDL with embodied cognition, investigating how students' embodied resources can be leveraged to promote equitable learning (Sasanelli et al., 2025), especially for students

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with disabilities (Tancredi et al., 2021). However, little is known about SBLVs' ways of knowing and how they can be leveraged to promote mathematics learning.

The context for this theoretical paper is a project that is connecting ideas from UDL and embodied mathematics learning to design and study mathematics learning opportunities for an international undergraduate student who is blind Oslund & Yu, 2023; Yu et al., 2024, 2025a, 2025b). Ian (pseudonym) has no vision in one eye and a small window of vision in the other, through which he can see very large print close up. We are studying his mathematical learning in multiple contexts (individual, small group, and whole class) across multiple semesters. As we analyzed video from these sessions to understand the student's ways of knowing and features of the instructional context that provided access and inclusion, we noted a few moments that seemed special in that they seemed to go beyond both access and inclusion. We began to earnestly study these moments, which we are calling *expansive*, to understand features that made them stand out and the instructional context that allowed them to happen. The purpose of this paper is to articulate a model for *expansive* mathematics learning that goes beyond thinking about disability, especially visual disabilities, in terms of accommodation and inclusion.

THEORETICAL BACKGROUND

Learning as participation. Learning may be described as becoming able to participate in discursive norms and routines of communities of practice (Wenger, 1998). The participationist perspective (Sfard, 2025) is often contrasted with the acquisitionist perspective—an idea that individuals who lack some knowledge acquire it from others (often teachers) who impart knowledge to them (Sfard, 2025). While an acquisitionist may focus on what knowledge a learner lacks and how it might be imparted, a participationist acknowledges that, because participation is linked to learning, all learners bring knowledge, identities, and practices to learning contexts. Each learner has a background through which he or she understands and interprets new experiences. In a participationist perspective, learning is defined by changes in participation and identity. As one learns the practices and discourses of a new community of practice and is judged on the ability to act and speak in ways that are endorsed by the community, one moves from a peripheral position in the community to one that is more central. Power and privilege are at play in this endorsement (or not) of particular ways of acting and speaking (Esmonde & Booker, 2017), which can affect who sees themselves (and is seen by others) as capable. In a culture of mathematics education, the ways of knowing that have traditionally been endorsed are those that conceive of mathematics and mathematical ability narrowly, creating exclusion (Louie, 2017). Attempts have been made to broaden the abilities recognized; for example, mathematics educators have been interested in incorporating multiple representations for mathematical ideas into our lessons to make learning richer and more connected, as well as to promote engagement and reach a diverse range of students; however, not all bodies can perceive all representations. Math is often treated as a visual subject,

which poses a barrier for SBLVs, requiring them to conform to sighted ways of knowing (Bayram et al., 2015).

Learning as embodied. The move toward understanding mathematical learning and knowing as embodied has emerged as math educators seek to democratize mathematics learning and understand ways different bodies are societally positioned (Gerofsky, 2016; Sinclair & Freitas, 2019). Research and theorizing on embodied cognition are currently being taken up across a wide range of fields and approaches (e.g. Gerofsky, 2016; Sinclair & de Freitas, 2019). Math education researchers have similarly begun to apply embodied cognition with SBLVs. For example, Gerofsky and Zebehazy (2022) used motion to help elementary students with visual impairments notice mathematically important features of graphs. When we say mathematics learning is *embodied*; we understand this as involving whole bodies (Gerofsky & Zebehazy, 2022). This is important to our collective responsibility for equity, requiring us to see diversity in bodies and their implications for learning. An embodied understanding of mathematics means that diverse bodies will bring diverse background knowledge and identities. Ways of speaking and acting that are endorsed as competent in math education have often been constructed around assumptions about being able to perceive visual representations and information.

Disability as Social and Embodied. Historically, the model of disability focused on differences as defects to be fixed or accommodated. This is referred to as the deficit model or medical model (Lambert, 2019; Lambert et al., 2018). From this perspective, disabilities are defects to be fixed or accommodated. The social model of disability critiques the medical model, holding that the social context is disabling. Ideas of normalcy around the human body have been constructed and ranked (Davis, 2013), and society has been set up around those ideas, which pose barriers to people whose embodied characteristics do not have the same status. The social model has been useful in determining barriers and seeking to remove them; however, it does not account for the embodied nature of disability (Lambert, 2019) and neglects the identity issues and challenges inherent in having a disability (Shakespeare, 2013). A critical take argues that disability is both socially constructed and embodied (Lambert, 2019). We seek to treat differences in bodies, including differences in perception, as strengths, and we have been seeking to better understand an SBLV's assets and ways of knowing.

CONNECTIONS TO RELATED LITERATURE

Accommodation. Some work has been done to provide access despite barriers in math education. Examples include providing audio description for videos, translating texts into Braille, and providing assistive technology. The goal is to adapt what is conveyed through sight into audible or tactile forms (Ahmed & Chao, 2018). However, this is often not done well; there may be errors in textbooks and discrepancies between SBLVs' and sighted students' materials (Bell & Silverman, 2019). This work is important, yet frames SBLVs as outsiders. Even with accommodations, more cognitive

effort may be required for SBLVs to understand mathematical concepts that rely on visual metaphors (Dick & Kubiak, 1997).

From a participationist lens, learning happens as one becomes able to act and speak in ways that are endorsed by the community; in math education, visual ways of knowing have been endorsed as competent. Although there are efforts to give SBLVs access to visual content, they do not change the rules or values of the community. SBLVs' ways of knowing are not well understood, and therefore, are often neither endorsed nor recognized as competent. Additionally, accommodations are often provided in one-on-one sessions with specialists in blind education or instructional aides, posing a barrier to full participation in the community of practice.

Inclusion. Whereas accommodations focus on individual differences, inclusion is about creating spaces where people with multiple different needs and ways of knowing can participate together. Universal design for learning (UDL) is a model for inclusion (CAST, 2024). UDL includes fostering collaboration, but less is known about how collaboration around alternative means of perception might look and sound, or how teachers might support it. UDL also recommends cultivating multiple ways of knowing, including kinesthetic. (Louie, 2017) argued that a culture of inclusion in mathematics classrooms includes conceptualizing the nature of mathematics as multi-dimensional and focused on sense-making. Her model also argues for the nature of mathematical ability as multi-dimensional and valorizing skills not traditionally endorsed as mathematically important.

BEYOND ACCESS AND INCLUSION TO EXPANSION

Based on the literature and our analysis of the video, we propose a model that goes beyond accommodation or inclusion to expansion--that is, expansive in terms of perceptual ways of knowing, curricular decision-making, and participation in the community of practice. Next, we describe these means of expansion and illustrate them with examples from our data.

Expansive in terms of the perceptual ways of knowing that are endorsed. As stated earlier, math is often conceptualized as visual, but not all bodies can perceive visual information. SBLVs are conscious of the inequities they are facing regarding not being welcomed, not having access, and not being included in mathematics education, "The students were asserting themselves as mathematics doers who were conscious of having their form of mathematics invalidated were aware that their right to self-determination in mathematics was being denied" (D'souza, 2017, p. 5). The following scenario took place during a one-on-one lesson on slope (Oslund & Yu, 2023). The instructor had Ian walk up and down three different sets of stairs to feel varying degrees of steepness. On the third set of stairs, Ian noted, "Vertical [height of a step] is, might be like longer, I mean taller, by inch maximum [than the second stairway]." The instructor said they should return to the second stairway to compare. As the instructor turned to go, Ian turned toward the current staircase and bent down, using his cane to

measure the height of the top step and marking the height on his cane with his fingers. He carried the cane that way to the second staircase, where he stopped, stooped, and placed his cane along the bottom step. “I told you, about an inch!” Ian said, chuckling. “Little bit, not even an inch.”

This excerpt stood out to us because it illustrated Ian’s embodied ways of knowing that those of us who are sighted had not considered--he was able to assess the height of individual steps and talk about them in ways that those of us who are sighted could not. This highlighted the importance of taking a curious, asset-based approach, including whole body ways of knowing.

In describing inclusive spaces, it has been suggested to conceptualize mathematics and mathematical ability expansively (CAST, 2024; Featherstone et al., 2011; Louie, 2017). However, these often still assume that mathematics is visual. Our model extends this work by suggesting notions of math and math ability that are expansive in terms of perception.

Expansive in terms of the nature of the curriculum. As an international student from a country without the resources to accommodate his blindness, Ian was studying math formally for the first time in years. The following lesson on parabolas (Yu et al., 2025a) took place early in his algebra course, a few sessions after the lesson described above. The instructor and Ian were again working one-on-one. Ian had no recollection of any prior learning about parabolas. This lesson used a puzzle consisting of a solid wood parabolic form and 15 wooden blocks that, when stacked in the right sequence along the wooden form, would result in a free-standing arch. The purpose of the lesson was to feel the curvature and symmetry of a parabola. However, this puzzle allowed for a more expansive investigation into properties of parabolas that extended well beyond the instructor’s lesson goals. Ian picked up the wooden arch form and traced his finger starting at the top, or vertex, of the arch and ran his finger along the axis of symmetry to the bottom of the wooden form saying, “Rise.” Then he moved his finger along the bottom of the wooden arch to one of the base corners saying, “Run. If I divide [the rise] by [the run], I will get this straight line to connect point A to point B,” tracing his finger along the line that connected points A and B. As he traced his finger along the parabolic curve making up the edge of the wooden arch, he said, “But when I divide the rise by the run, I won’t get this curvy slant. How do you measure that curvy slope?” The instructor then shifted the lesson toward related calculus concepts by having Ian touch and recognize that the inside edges of the arch’s blocks represented slopes of tangent lines along the parabola, or the first derivative.

Math is often conceptualized as a discipline in which concepts must be taught in order; algebra class must be completed before studying calculus. However, our work causes us to question that necessity. Even when accommodation and inclusion are desired, assumptions about what math should be taught are still fairly narrow, considered to be a trajectory that students complete in order. However, we propose a model of expansive learning in which the students’ ways of knowing and the curriculum influence each

other, facilitated by an instructor with the necessary mathematical knowledge to connect the students' interests to math that they will need to participate in their chosen community of practice.

Expansive in terms of participation in the community of practice. Another way to consider the previous scenario is that the authority has shifted from a model where the teacher is the sole decision-maker to one that allows the student authority over the content for study (Bishop et al., 2025). In thinking about this from a participationist lens, we argue that the goal is not only to prepare people to participate in a community of practice but to contribute to the community of practice.

Consider the following lesson, in which Ian was working in a study group with two other students who were sighted. The class had previously done a lesson on how exponential functions are affected by algebraic transformations, in which Ian did not have access to the computer-based visuals; the other two students had emerging understandings of the content (Yu et al., 2025b). The instructor engaged the small group together in using tactile graphs with "Wikki Stix" (wax-coated yarn that can be sculpted) on embossed graph paper to explore how exponential functions are affected by algebraic transformations. The group also did calculations in a digital Jamboard, which Ian accessed on large screen that he could view at very close range, while the other students accessed it on tablets. The instructional materials centered Ian's ways of knowing, but were accessible to all, allowing all three students to work at the same pace and fostering collaboration and discussion. This positioned Ian's ways of knowing as central to and endorsed by the community of practice.

IMPLICATIONS

Through a participationist lens, learning is changing participation and identity as one becomes able to participate in a community of practice by acting and speaking in ways that are endorsed by the community (Wenger, 1998). With a STEM undergraduate student like Ian, that is the goal--to be perceived as knowledgeable and able to participate in a STEM career. However, our model goes beyond this, to question assumptions about the ways of knowing that are endorsed and marginalized. We want Ian not only to be able to participate peripherally in the STEM field he has chosen, but to perceive himself and be perceived by others as capable of contributing to the communities in which he participates. Key to making this possible was understanding that mathematics learning is both social (within a community of practice) and embodied, which we understand as involving the whole body.

Working with Ian forced us to reckon with the consequences of a visual presentation of math. It can be difficult to imagine learning communities where mathematical knowing is expanded beyond the visual. Our study demonstrates some ways this is possible. We saw improved, impactful, joyful learning for everyone by centering the learning of the student with the disability e.g. (Lambert, 2021; Tan et al., 2022).

Of course, accommodation and inclusion are still necessary; we see expansion as building on these. In our data, we found many lessons were characterized by accommodation and inclusion, and a few that included moments of expansion. And yet, we argue that these moments are worth striving for. There are systemic challenges to promoting expansion in teaching SBLVs and other students with disabilities. In our context, the SBLV sometimes worked individually and in small groups with the instructor; this is often the case, as SBLVs are often supported outside of the classroom. However, our context was unique in that the instructor had deep knowledge of mathematics; this is often not the case for instructors of SLBVs (cite). Further research should seek to understand the mathematical knowledge for teaching SBLVs.

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