# ADDRESSIVITY IN GESTURAL COMMUNICATION ABOUT MATHEMATICS

Marijke Campbell

Simon Fraser University

*This paper argues that Bakhtin's concept of addressivity (the orientation of the speaker toward an addressee) can enrich interactionist gesture models to explain why gesture scale changes during mathematical communication. The analysis shows that during moments of conflicting perspectives of mathematics (in asymmetric engagement), recapitulations occur alongside larger, whole-body gestures. Conversely, when children share the same perspective on mathematics (in symmetric engagement), they produce small-scale gestures with recapitulations. Shared perspectives are seen to coincide with children's adoption of the other's gestures (hereafter, a gestural relation of agreement). The analysis argues that, in a Bakhtinian sense, speaker gestures are anticipatory, responsive, and multi-voiced.*

## GESTURES IN MATHEMATICS EDUCATION

Gerofsky's (2011) study on student-elicited gestures highlights differences in styles of gesturing, and not just content. In particular, differences arise in terms of the scale of gestures (small or large), which Gerofsky linked to gesturers' knowledge. This paper explores the idea that the scale of a gesture can also be linked to the audience. That is, what and how you gesture depends on whom you are speaking to.

Using a cognitive science perspective, Hostetter and Alibali (2019) argue that the form and scale of gestures are determined by the gesturer's perspective when expressing information. Indeed, most research on gesture scale relies on an action-perception model and a gestural threshold to determine the frequency and function of gesturing, with a primary emphasis on the individual's motivations for producing gestures.

However, as inherently communicative acts, gestures must also be shaped by *both* interlocutors—the makers and the receivers. To explore this hypothesis, this study expands Mikhail Bakhtin's concept of addressivity (orientation towards another) beyond linguistics to encompass the embodied concerns of gesture research, enabling an analysis of the social contexts in which interactional gestural communication occurs. This is important because changes in gesture scale during mathematical communication may not be solely linked to the speaker gesturer's knowledge (Gerofsky, 2011) but may also provide teachers with subtle cues about the *addressee's* understanding or perspective on the mathematics.



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## A DIALOGIC AND INTERACTIONIST FRAMEWORK

Although usually used in more linguistically focused research (Pimm & Sinclair, 2009), Bakhtin's concept of addressivity can also be applied to gestural communication intended for an audience. Three key principles of dialogism are relevant to understanding and engaging with others. First, language is a social construct; thus, analyzing discourse within a dialogic framework requires attention to both participants in the interaction. Second, this dual focus reveals that the speaker is shaped by the discourse just as they anticipate its impact on the listener. This reciprocal influence highlights the intricate interplay between subjective and intersubjective factors that shape each communicative turn. Finally, every utterance is composed of multiple voices (Bakhtin, 2010). These voices are reflections of what the addressee or anyone present in the speech situation might say, which would affect the form of the utterance. As Bakhtin suggests, the embodiment of a word gives it dialogical status.

While communication between a speaker and an addressee is personal, it often incorporates speech that maintains a dialogical relation of agreement with prior speakers and dialogue (Bakhtin, 2010). This paper extends this dialogic reciprocity to gesture, drawing on Streeck's (2009) conceptualization of gesture as part of a shared, mutual orientation between individuals. While every utterance is composed of multiple voices, communicators also engage in practical actions, such as idiosyncratic movements or gestures drawn from prior social interactions, this paper argues, in a Bakhtinian sense, that gestures are anticipatory and responsive, and that they coexist with multiple voices and perspectives (heteroglossia).

Speakers will structure their bodily behaviour in response to whether and how others are observing them (Streeck, 2009). From a linguistic perspective, Spronck (2020) notes that when a speaker asserts epistemic authority, they typically preface their communication with a subject marker, "I", thereby positioning themselves as possessing an understanding that the listener does not, indicating asymmetric engagement. On the contrary, when a speaker lacks epistemic authority, it signals a shared perspective of the topic and indicates a symmetric engagement between the speaker and the addressee. By analyzing children's gestures during communication with both perceived unfamiliar (mixed-aged, with potential epistemic authority) and familiar (similar-aged, potentially without epistemic authority) audiences, this study examines how children's style of gesturing depends on their addressee.

Addressivity provides an exploratory lens to how gesture scale could be modulated by the speaker's orientation towards the addressee. If addressivity shapes gesture, it should be evident in gestural scale changes during moments of shared versus multiple perspectives on the mathematics, in gestural adoption during moments of symmetric engagement (when voices/perspectives are shared), and in scale changes correlated with shifts in epistemic authority. Dialogical relations of agreement in communication highlight the co-creation of meaning through multiple perspectives and prior voices;

though, within communication, we must also attend to gesture. When different perspectives on mathematics coexist during asymmetric engagement:

1. How are children's gestures affected during the communication of mathematics with differing perspectives during asymmetric engagement?

2. How do the above-mentioned gestures compare to children's gestures during moments of shared perspectives on mathematics during symmetric engagement?

## PARTICIPANTS AND PARTICULARS OF THE STUDY

This study employs a naturalistic observation research approach, allowing gestures to emerge in authentic dialogic interactions and to reflect addressivity. School-aged children (5–12 years old) are paired in two contexts to discuss math with peers of similar and different ages. Mixed-age and same-age pairings were selected to create potential asymmetric and symmetric engagement contexts to determine whether speaker gestures differ depending on the addressee's perceived knowledge state in mathematics. Each child participated in two sessions: one with a child of a similar age and one with a child of a different age. Due to scheduling, one child participated in two sessions with children younger than themselves.

In total, twelve sessions capture children engaging in purposeful communication pairings with other children. Each session lasts approximately 20 minutes, during which children discuss different mathematical topics to avoid priming effects. In one session, they are asked to discuss "what is addition?" and "what is an angle, and in the other, they are asked to discuss "what is a circle?" and "what is a cube?" Multiple mathematical topics were chosen to ensure that patterns of gestural interaction were not topic-specific but rather reflected the children's ongoing dialogical and gestural engagement with one another.

To help children become comfortable speaking with each other and minimize interaction with the researcher during the observation period, they were encouraged to practice asking each other introductory questions, such as "what is your favourite colour?" before the sessions began to create an environment in which the adult researcher had less influence on the children's communication during their mathematical dialogue, and that the two children could authentically interact.

## ANALYSIS

The following tables outline the engagement contexts observed among children of similar ages (see Table 1) and those of mixed ages (see Table 2). Noted in both tables, asymmetric engagement was observed as present when: 1) One child verbalised they did not understand the mathematics and thus delegated epistemic authority to the other; 2) A child appeared unsure about how to start discussing the mathematics topic and consequently delegated epistemic authority to the other; and 3) There were differing perspectives on the mathematics being discussed (children clarifying or asking the other "does it count as [the mathematics in this new context?]"). Noted in both tables,

symmetric engagement was observed as present when: 1) Children were nodding in agreement or saying “yes” to another child's perspective of the mathematics; 2) There was no addition of a new perspective of the mathematics to the dialogue; and 3) There was a lack of epistemic authority. Finally, gestures are classified as large if they involve stretching and extending the arms and bending or moving the body. In contrast, small gestures involve restricted hand movements with limited involvement of the rest of the body.

Table 1: Same-age pairings show a small overall gesture scale

| Similar-aged pairings | Symmetric Engagement & Co-occurring Gesture Scale | Asymmetric Engagement & Co-occurring Gesture Scale |
|---|---|---|
| 11 and 11 | Present - Small | N/A |
| 8 and 8 | Present - Small | Present – Large |
| 10 and 11 | Present - Small | N/A |
| 8 and 8 | Present - Small | Present – Large |
| 8 and 7 | Present - Small | Present – Large |

Table 2: Mixed-aged pairings show a small overall gesture scale

| Mixed-aged pairings | Symmetric Engagement & Co-occurring Gesture Scale | Asymmetric Engagement & Co-occurring Gesture Scale |
|---|---|---|
| 7 and 5 | Present - Small | N/A |
| 10 and 5 | Present - Small | Present - Large |
| 11 and 8 | Present - Small | N/A |
| 11 and 7 | Present - Small | Present - Small |
| 10 and 8 | Present - Small | Present - Large |
| 11 and 8 | Present - Small | Present - Large |
| 10 and 7 | Present - Small | N/A |

Initial perceptions of age differences did not inherently affect the scale of gestures in the communication of mathematics; instead, the ongoing dialogue and gestures indicated whether the engagement became asymmetric.

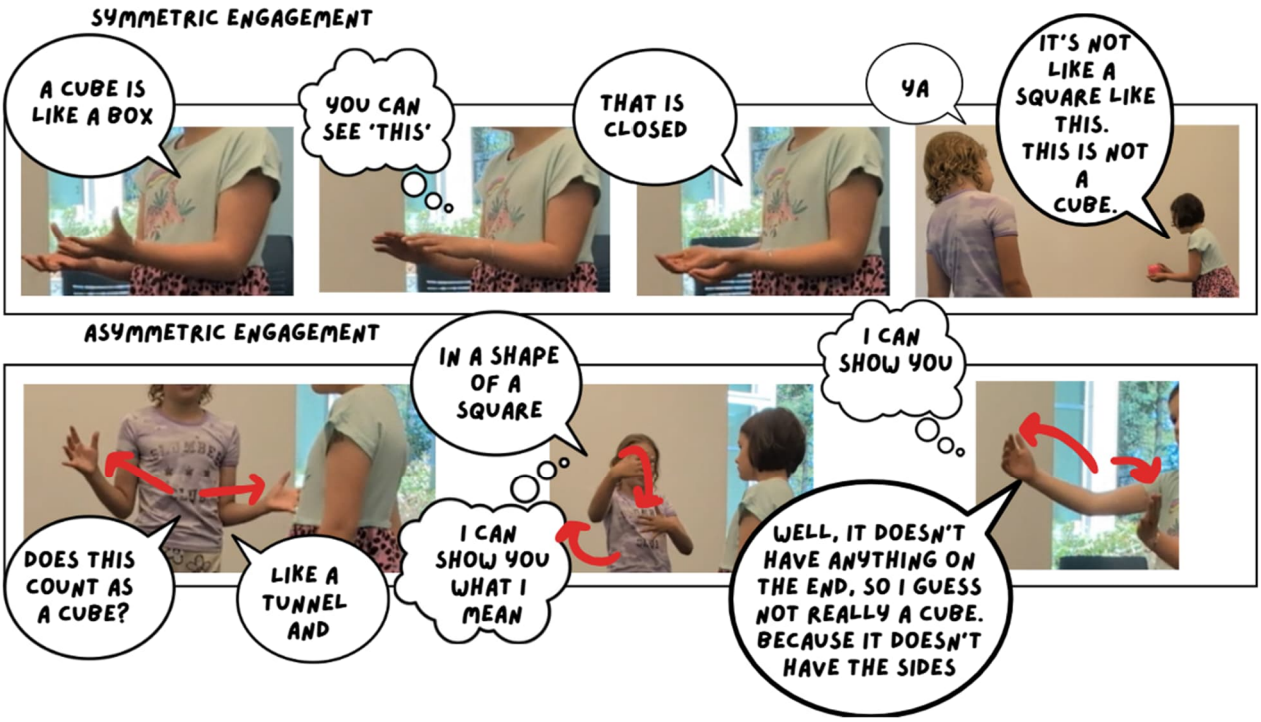
With a significant age gap (5 years), one older child initiated communication with their younger counterpart, using large gestures at first. However, when older children with smaller age gaps, such as eight and ten-year-old pairings, initiated the conversation, they did not immediately engage in large gestures. This could be explained by the older child perceiving that the mathematics topic discussed with the younger child was something they already had a perspective on (for example, what is a circle?).

Symmetric engagement in Table 2 across mixed-aged pairings was maintained until the younger child said, “Does it count [as the math in this context?]” which dialogically granted the older child epistemic authority over the younger child, at which point large-scale gestures appeared. In one mixed-age pairing, the younger child granted epistemic authority to the older child, and the older child did not gesture largely. Instead, the older child built their perspective on the mathematics for their younger partner using found items in the room: a cube made from magnetic shapes while discussing its faces.

In contexts where children were similar in age, or when the younger child in a mixed-aged pairing spoke first, they often began communicating in a symmetric engagement. In these moments, children used smaller-scale representational gestures during recapitulations, indicating shared perspectives of the mathematics between the speaker and their addressee. An example of a small-scale gesture in symmetric engagement (shared perspectives) is shown in Figure 1, line 1, below, where Avery nods and says “yes” in agreement with Emma’s statements about a cube being “like a box”.

Symmetric engagement shifts to asymmetric engagement when a disagreement or difference in perspectives on mathematics occurs. The effect of this change in engagement on the gesture scale is shown in Figure 1, line 2, when Avery uses large, depictive gestures to ask Emma whether a tunnel can be considered a cube. Emma responds with a larger, depictive gesture to clarify that it could not be a cube because it would be missing two of the six sides.

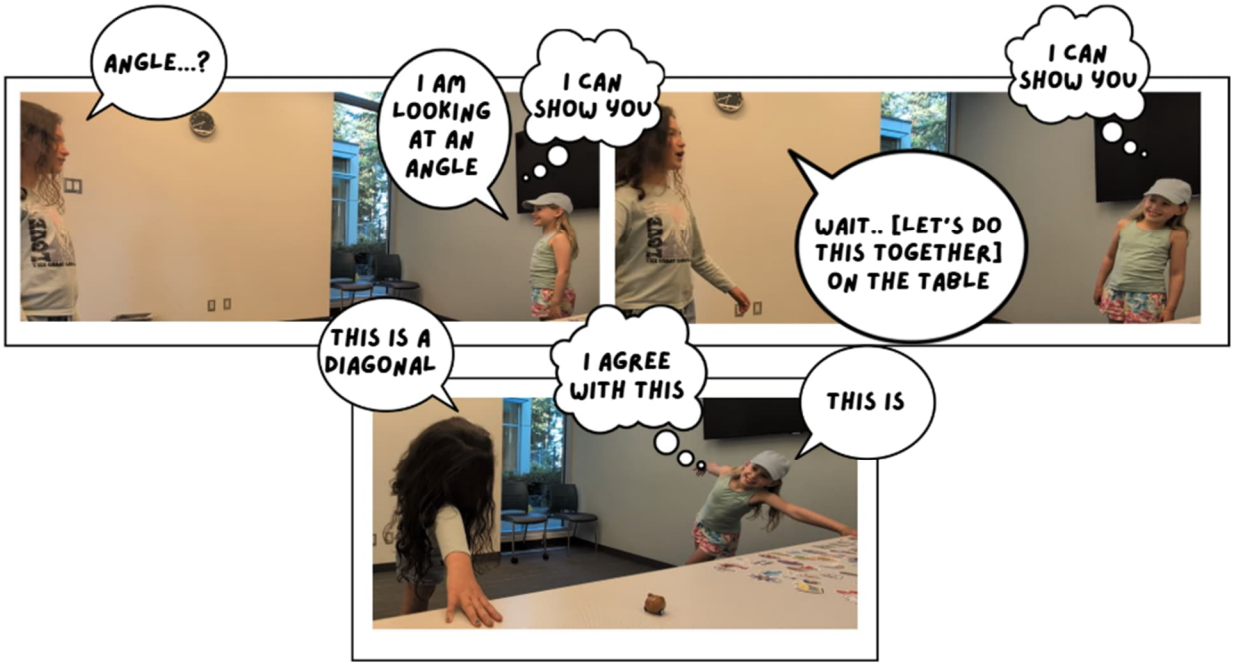
Figure 1: Symmetric engagement shifts to asymmetric engagement




Large gestures also emerge when a child is initially unsure about mathematics. In Figure 2, Mia appears unsure how to discuss an angle with her peer of a similar age. Charlotte notices her uncertainty and positions her body to angle toward Mia, then

repeats by leaning her whole body while facing Mia to help her see her perspective of the angle. Symmetric engagement is restored between Mia and Charlotte through a dialogical and gestural relation of agreement in this communicative context, as shown in Figure 2 below. Here, Mia shares her view of an angle, incorporating Charlotte's prior leaning gesture on the table, and adds the word "diagonal" to the discussion about the angle. Figure 2 thus displays a reciprocal exchange of ideas, in which Mia introduces the perspective of "diagonal," allowing multiple perspectives of mathematics to coexist. Thus, this leaning gesture on the table is multi-voiced, sharing both Charlotte's and Mia's perspectives of angle and diagonal.

Figure 2: Large gestures with recapitulations result in a gestural relation of agreement




Finally, asymmetric engagement was also evident when one child granted epistemic authority to another by verbalizing that they did not know the mathematics. In Figure 3 below, Mike and Elise are shown talking about the faces of a cube. After Mike says, "I don't know [what a cube is]," Elise starts gesturing largely to create imagery about the square-shaped sides of the cube. Elise then recapitulates with a square toy she picks up from the table and finally counts the walls of the cube-shaped room. At this point, Mike joins her in a gestural and dialogical relation of agreement by adopting her diectic gesture while counting the sixth and final side. This indicates that dialogical and gestural relations of agreement are also evident during a shift from asymmetric engagement in mathematical communication to symmetric engagement with children of mixed ages. In this example, the *responsivity* of a gesture can be seen. When Elise notices Mike adopting her diectic gesturing and dialogue, she starts to lower and pull her gesturing finger back towards her body. Elise no longer stretches her arm in a large diectic gesture above her head to show Mike the final face of the cube, as he now *sees* the mathematical property of six faces along with Elise.

Figure 3: Elise's gesture is responsive to Mike's gestural relation of agreement

## DISCUSSION

Gestures in communication become larger in asymmetric engagement between the children and remain smaller in symmetric engagement. This variation in gesture scale during these engagement contexts suggests that addressivity—the orientation between the speaker and the addressee in mathematical communication—influences children's gestural size. Gestural engagement between children is elastic and adjusts during co-occurring dialogue in response to the speaker's awareness of their audience's perspectives of the mathematical concepts in the current context.

Children use linguistic recapitulations along with gestures in communication with their addressee (See Figures 1–3), demonstrating how prior dialogue and gestures with similar communicative intent influence the present discourse. These recapitulations occur across asymmetric and symmetric engagement contexts with children, representing an increased intersubjective investment in the addressee's knowledge state. In symmetric engagement, smaller gestures often co-occur with recapitulations, indicating shared perspectives of the mathematics between the speaker and the addressee. This is evident when Emma's first gestures are small yet depictive to Avery (her audience) when they speak about cubes (See Figure 1, line 1). Alternatively, large-scale gestures and recapitulations arise in asymmetric engagement in mathematical communication with children, in which the speaker gestures to demonstrate or clarify something mathematical to an unfamiliar audience or add a new perspective on the mathematics. This is evident when Emma uses larger, depictive gestures with recapitulations to highlight aspects of the mathematics for Avery (see Figure 1, line 2), Charlotte's large, whole-body gestural recapitulations for Mia when talking about angles when Mia seems unsure (see Figure 2) and Elise's large depictive gestures with Mike when he says "I do not know [the math]" (See Figure 3).

Listeners do not just respond to an utterance after it is made; they also shape it while it is being made. Addressivity also includes an utterance's implicit dialogue with earlier utterances on the same topic, where words carry their contexts and dialogical agreement with previous speakers (Bakhtin, 2010). While in symmetric engagement, children are seen to adopt/mimic other children's gestures in a gestural relation of agreement. An example of this is when Mike adopts not only Elise's counting dialogue (see Figure 3) but also her co-occurring deictic gestures. Another example is shown in Figure 2, where Mia and Charlotte use large whole-body gestures during asymmetric engagement, initially when Mia seems unsure, and when Mia offers a different perspective of an angle, exchanging ideas to arrive at a newly shared perspective on angles. During this dialogical relation of agreement, Mia adopts and uses Charlotte's leaning whole-body gesture with a different perspective of angle in mathematics, seeing it as a *diagonal*. Charlotte not only agrees with Mia's perspective dialogically by saying "yes" but also gesturally, by reciprocating Mia's gesture of a whole-body lean on the table back towards her. Gesture is thus seen to be *anticipatory* of a listener, *responsive* to ongoing dialogue and incorporates the *multiple voices* of past interlocutors.

## FUTURE RESEARCH

Being aware of children's gesture style can help teachers identify when children are aligning, joining, or struggling to express their mathematical ideas. This study demonstrates that large gestures occur not only when the speaking child is knowledgeable about mathematics, as described by Gerofsky (2011), but also are closely linked to their audience—appearing during meaningful efforts to support a peer's understanding; to merge differing perspectives on mathematics; or when a child is clarifying their mathematical views. This dialogical and interactional nature of gesture, as viewed through the lens of addressivity, highlights the importance of intentionally pairing children in collaborative math learning discussions, where teachers should encourage children to demonstrate, repeat, and expand on each other's gestures and perspectives on mathematics.

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