Capturing the use of Key Word Sign in Early Childhood Mathematics

Kate Quane
Adelaide University
Kate.quane@adelaide.edu.au

Belinda Trewartha
Adelaide University
Belinda.trewartha@adelaide.edu.au

Lorraine Gaunt
Charles Sturt University
lgaunt@csu.edu.au

Elaine Stigwood
Sunshine Sign and Sing
elaine@sunshinesignandsing.com.au

Zoe Wadsworth
Sunshine Sign and Sing
zoe@sunshinesignandsing.com.au

This paper examines the use of Key Word Sign (KWS) as an inclusive strategy for early mathematical learning. Reporting on phase three of a multi-stage project, it explores how staff and children enacted KWS in an early learning centre. Two main approaches were identified in how children and staff used KWS in mathematics: 1) intentional and deliberate, and 2) spontaneous and responsive. These approaches were used during structured activities and play, enhancing access to mathematical language, strengthening spatial reasoning and promoting multimodal communication. Findings position KWS as a valuable strategy for inclusive embodied mathematics pedagogy.

Introduction

Supporting children's access to early mathematics remains a persistent challenge, with longstanding research highlighting disparities in children's opportunities to engage meaningfully with mathematical ideas, language, and practices (Lee & Ginsburg, 2009). These challenges are amplified by variation in educators' confidence and pedagogical content knowledge (MacDonald et al., 2023). In addition, children bring diverse communication needs (Brebner et al., 2016). As a result, children's early encounters with mathematics can differ significantly in quality and accessibility, shaping their developing identities, dispositions, and participation (Lee & Ginsburg, 2009).

The development of children's mathematical language is central to their emerging mathematical understanding, as language is seen as a tool through which young learners make sense of quantity, space, pattern, and relationship (Verdine et al., 2017). Early mathematical language supports children to articulate their thinking, participate in mathematical dialogue, and engage in mathematical situations (Verdine et al., 2017). Research consistently shows that children's exposure to rich mathematical language varies widely, with significant implications for later achievement (LeFevre et al., 2010). Consequently, supporting children's mathematical language development requires intentional, inclusive pedagogies that recognise communication as embodied, relational, and deeply intertwined with conceptual growth.

Key Word Sign (KWS) is an embodied communication approach that formalises the use of gesture as a core component of meaning-making (Quane et al., 2025). In the Australian context, KWS draws on signs from Australian Sign Language (Auslan) together with natural gestures to visually emphasise key words within spoken sentences. As such, KWS is a widely recognised form of unaided Augmentative and Alternative Communication (AAC). Research demonstrates that combining manual signs with speech can strengthen communication and support speech development for individuals with developmental disabilities (Cruz Leon & Zorn, 2024). Importantly, the benefits of integrating gesture with spoken language extend beyond specialised contexts, with evidence showing positive outcomes for typically developing children, including gains in literacy, foreign language learning (García-Gámez & Macizo, 2023), and mathematical

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understanding and retention (Kersey et al., 2024). Together, speech, sign, and gesture form a semiotic bundle referred to as a multimodal repertoire that enhances children's agency and supports the expression and consolidation of conceptual understanding. KWS has long been used to support children with diverse communication needs. A clear gap remains in understanding its broader pedagogical protentional, particularly in early mathematics. By reimagining KWS as part of everyday teaching practice, we foreground its capacity to broaden access to core mathematical concepts, strengthen inclusive learning environments (Cologon & Mevawalla, 2018), and honour longstanding traditions of embodied, gesture-rich communication that have always been central to how young children make meaning (Kim et al., 2011). In the early years, where foundational mathematical concepts are formed, the integration of KWS can deepen conceptual understanding while ensuring equitable access to emerging mathematical language.

In this paper, we report on phase three of a multistage project. The initial phase identified 20 KWS that had a mathematical focus on location, specifically position and direction (Quane et al., 2025). Phase one investigated the context of the Early Learning Centre, gaining insights into the mathematics program, exploring teachers' initial understandings of KWS, and documenting their current use of KWS in everyday practice. Phase two focused on supporting teachers' implementation of KWS in mathematics through targeted professional learning and resources. Phase three examined the enactment of KWS in practice, with a specific focus on teachers' and children's use of KWS related to position and direction. This final phase explored how KWS supported children's engagement with spatial language and concepts, capturing both pedagogical practices and children's multimodal mathematical communication. Findings from Phase three are the focus of this paper, answering the following research question: *How do teachers, educators and children use Key Word Sign, and in what situations do they use KWS to communicate their mathematical ideas?*

Spatial awareness, reasoning, and embodied cognition in the early years.

Spatial awareness and reasoning are foundational components of early mathematical development, supporting children's ability to interpret, navigate, and make sense of their world. It is widely recognised that spatial awareness and reasoning underpin later mathematical achievement (Sarama & Clements, 2009). Furthermore, the specific vocabulary related to position and direction has been found to support the formation of mental models that scaffold later mathematical learning (Pruden et al., 2011). Research consistently highlights that spatial thinking emerges early in life and develops through rich sensory–motor experiences, interactions with objects, and engagement in spatial language (Verdine et al., 2017). In the early years, spatial awareness encompasses children's understanding of location (e.g., *in*, *on*, *under*), and direction (e.g., *forward*, *around*, *towards*), forming the basis for more complex skills such as map reading, and problem solving (Sarama & Clements, 2009). Everyday play activities, such as block building, puzzles, construction, and navigating spaces, provide critical opportunities for children to develop flexible spatial representations and make predictions about objects and movement. Educators' use of spatial language during these activities has been shown to significantly enhance children's conceptual development, with specific vocabulary related to position and direction supporting the formation of mental models that scaffold later mathematical learning (Pruden et al., 2011). Within early childhood education, intentional teaching of location, specifically position and direction, plays a vital role in strengthening children's spatial reasoning and supporting equitable access to mathematics (Lowrie et al., 2017). Furthermore, research emphasises the importance of embodied and multimodal learning approaches, where children use gesture, physical movement, and manipulation of materials to externalise and refine their thinking (Kim et al., 2011; Way & Ginns, 2024).

Theoretical Framework

Universal Design for Learning (UDL) is an educational framework that guides the proactive design of learning experiences. UDL is organised around three core principles: 1) multiple means of engagement; 2) multiple means of representation and 3) multiple means of action and expression. These principles are further organised into ways to; a) increase access, b) to support the learning process and c) support learners' executive functioning (CAST, 2024). Each principle is divided into specific guidelines with accompanying considerations that provide more detailed guidance. UDL challenges a one-size-fits all approach by advocating for a flexible, inclusive learning designs that respond to students' varied strengths, interests, and needs (Navaitienė & Stasiūnaitienė, 2021). UDL is not widely used in the early childhood sector. However, clear links between UDL and the Early Years Learning Framework 2.0 (EYLF2.0) (AGDE, 2022) are seen. UDL's emphasis on multimodality aligns with semiotic perspectives that view learning as mediated through signs such as images, gestures, symbols, and tools (Radford, 2003). By providing multiple representational and expressive pathways, UDL acknowledges that learners construct meaning differently based on available semiotic resources and lived experiences (Morgan, 2006). This alignment is reinforced by EYLF Outcome 4, which positions children as confident learners who use diverse modes and materials to explore and communicate ideas (AGDE, 2022).

Methodology

Three types of observations were conducted in the preschool setting, drawing on the observational framework developed by Quane (2025). Descriptive, focused, and selective observations were undertaken throughout the project, with attention to both pedagogical practices and the integration of KWS. Broad descriptive observations of the preschool environment were initially conducted to capture the physical layout, available materials, planned activities, participants, and routines. These sessions, carried out before and after focused observations, occurred outside of children's attendance to allow accurate documentation of contextual variables and collaboration with staff in clarifying details. Field notes and a structured observational protocol supported systematic recording (Quane, 2025). Focused observations were conducted at regular intervals and documented teacher practices, with particular attention to the use of KWS during instruction and interactions. These observations also recorded the objects, artefacts, and mathematical resources used, alongside key events such as the teacher modelling signs like through and around to support children's comprehension (Spradley, 2016). Selective observations were employed to capture specific children's engagement, documenting the actions they performed, the materials they used, and how children responded to teachers' signing and verbal prompts (Quane, 2025; Spradley, 2016). Observations were conducted by three members of the research team. An observational protocol and field notes were used to record the observations. Photographs documented situations where staff and children used KWS in mathematics. The observations reported in this paper, arise from the three types of observations occurring in one session lasting three hours.

Learning Stories

A learning story attempts at capturing the curiosity and knowledge of a learner, through the eyes of a teacher. It begins with a narration of a child's initiative in a given context followed by an analysis of the possible understandings and learning that one or more children are engaged. Carr and Lee (2012) identified the following four design principles in developing a learning story: 1) position learners with agency; 2) include multiple voices; 3) provide navigation markers for learners, both backward looking and forward looking, and 4) integrate dispositional and subject knowledge and practice. A key aspect of learning stories is that they "resist deficit positioning" (p. 138). Learning stories comprehensively documents a moment in time and multiple learning stories can demonstrate growth as attained by a child. Thereby, making the child's learning visible through skilful observations, sample photographs and analytical reflections. At the root of any learning story is a genuine interest in understanding a child's lived experiences and the process of articulating and documenting this as evidence of learning. As such, learning stories can be quite subjective wherein a teacher can focus on strengths and abilities of a child and provide comprehensive detail about a child's initiated or unplanned sequence of events and its impact on the student's own learning. Learning stories gives educators a licence to add value by incorporating their interpretation of a child's thoughts, emotions, and body language (Carr & Lee, 2012). The learning stories document two key approaches to using KWS in mathematics. First intentional and deliberate. Intentional refers to actions that are purposeful and planned, guided by clear goals or learning intentions (AGDE, 2022, P.17, 18, 48). Deliberate practice refers to conscious, systematic and conscious actions to achieve a specific purpose. The second approach has been classified as spontaneous and responsive use of KWS. Spontaneous refers to actions that occur naturally and unplanned in the moment, arising without prior intention or structured preparation. Teachers optimise spontaneous, teachable moments that arise from learners' need in play, comments, actions and everyday routines to scaffold children's mathematical learning (AGDE, 2022, p. 17). Being responsive to these moments is an important basis for curriculum decision-making in response to children's evolving ideas and interests (AGDE, 2022) and involves noticing, wondering, interpreting and acting on not only what, but how children communicate.

Research context and participants

The study was situated in a single ELC in a regional city in Southeast Queensland. Data reported in this paper was drawn from one kindergarten room enrolling three to four-year-old children. Two teachers, Grace, the room leader, and Jane, had both been at the ELC for seven years. Both teachers had engaged in targeted professional learning focused on the use of KWS to support the development of mathematical language. Room one at the ELC provides a foundational early childhood learning environment for children aged three to four years, designed to consolidate emerging competencies and foster positive dispositions toward formal education. Positioned as a critical stage within the centre's broader play-based curriculum, the ELC prioritises exploration, creativity, and interpersonal development, recognising that cognitive, social, and emotional capacities are interwoven during the early years. Children in room one engage in open-ended experiences that foster curiosity and self-expression, supported by strong educator–child relationships. Learning is embedded in everyday social interactions and an integrated approach that honours individual development while supporting smooth transitions to kindergarten. Learning stories are used to document children's learning.

Findings

Observations were conducted in November 2025 on a Friday morning. Staff and children were beginning to prepare for end of year Christmas celebrations and preparing a concert item. The observations began after a morning tea break. Video and photographs of the children were not permitted due to recent critical issues in the sector around child protection. In analysing the observational data, two key approaches were identified through which teachers and educators went about incorporating KWS in mathematics in activities. In presenting the findings pertaining to children we use learning stories as a mechanism to identify the context and how children use KWS to communicate mathematical ideas and understanding. Our intention in sharing these learning stories is to document and illustrate two different examples, intentional and spontaneous, of how KWS in mathematical learning occurs in an ELC. Our intention is not to provide deep analyse of the learning.

Intentional and deliberate use of KWS

In preparing for the concert, the teacher led the children in a sign and sing session involving a song created by Sunshine Sign and Sing (authors 4 and 5). The song 'At the zoo' used the KWS for open and close, forward and backward, under and over, in and out, through and around. The song also used KWS of animal including crocodile, snake, monkey and gecko. The teacher intentionally planned for the signing and singing session to occur after the break with the goal of providing an opportunity for children to rehearse the concert performance. KWS used by the teachers and children have been *italicised*. The following learning story captures deliberate use of KWS:

A learning story about out, outside and inside

The children are sitting on the mat facing the teacher who is sitting on a chair. The teacher leads the children in two songs that use KWS. After signing and singing, the teacher gives instructions about going outside: "When I say get your hats *out* of your bag… then we will go *outside*. Some children begin to stand and move towards the door. The teacher redirects the children and again uses KWS in her instruction "not yet, we are *insid*e". The teacher indicates the area where the children will go, and a child asks why that area. The teacher responds with "the *babies* in the baby room will be sleeping *inside*." As the teacher signed the KWS for out, outside and inside, several children also signed the KWS. Two children used a pointer finger rather than a flat hand when signing the KWS for outside and inside.

Analysis of Learning

The use of KWS enhanced the teacher's instructions, providing a visual cue for the children. As children listened to the teacher's instructions, some copied the KWS, providing them with an opportunity to practice the signs and see their application. As children signed the KWS for out, outside and inside, variation was noted in the production of the sign, indicating that there may be a progression in how children use KWS particularly regarding handshape and orientation.

Spontaneous and responsive use of KWS

KWS used by the teachers and children have been *italicised*. Spontaneous and responsive use of KWS in mathematics occurred for both teachers and children as captured in the following learning story:

A learning story about up, down, under, above, through and around

Three boys are playing in the block corner (a collection of wooden blocks of various shapes and sizes) and are constructing a wall. One boy says, "let's build the wall up". Nearby, another group of children are with an educator constructing a marble run (between the television and the block wall, figure 1). The three boys co-constructed their wall and began to add a tower. One boy says, "let's make it higher," and adds a block to the tower. The educator, observing the boys, asks, "is it *abov*e your head?". The boy who expressed the desire to make it higher stands in front of the wall and says "no". The boy pauses, looks at the tower and places his hand on top of his head and measures from his head to the tower. As he measures, his hand moves in an upward and not level direction to his head. He looks over at the educator who intervenes stating, "you need to bring it *down*" signing the KWS *down*. The boy removes the block. One of the other boys suggests "let's make a ramp to go *down*". The three boys find a wooden truck with a long tray base, experimenting with different configurations of the ramp and rolling cars down it. The boys continue to experiment with the incline of the ramp and decide to make to flat. The educator asks, "What can you find to go *under* it at this end?" pointing to the lower end of the ramp. The boys roll cars across the ramp, watching them stop midway. They decided to change the incline of the ramp. They place a block under one end of ramp. One boy says, "we need another block *under* the ramp", pointing to the first block. He goes to the block storage area and finds another block of the same size (Figures 1 and 2). The two other boys place cars on the ramp, watching them roll down the ramp and fall off at the end of the wall.

Figures 1 – 3

Children's block play construction

Figure 1: Rear view of the constructed block wall

Figure 2: Side view of the constructed block wall

Figure 3: Front view of the constructed block wall

As the two boys continue to roll cars down the ramp, the third boy begins playing with a truck, driving it through the space in the wall (Figure 1). The boy moves to the front of the wall (Figure 3) and continues to drive the car around on the floor. He continues driving the truck through the space and around the space in front of the wall. "Look, I can drive the truck *through* here", gesturing by using his hand (pointer finger and moving his hand in a forward direction). Meanwhile, the two boys have found a basket and have placed it at the end of the wall (Figure 3). They place cars at the top of the ramp, watching as they roll down and then fall into the basket.

Analysis of Learning

This learning story captures rich moments of collaboration, problem-solving, and multiple modes of communication as the boys engage in construction and experimentation. The educator's intentional use of an open-ended question and KWS supports both language development and conceptual understanding. The educator modelled the use of signs (*up*, *above* and *under*) during the play. Through parallel play, the children explored spatial awareness using appropriate mathematical language to describe the position and direction of the cars, the ramp and the basket. The children's persistence in adjusting the ramp's height, identifying suitable materials, and testing outcomes highlights developing dispositions of curiosity, persistence, and cooperation.

Discussion

The observations illustrate how Key Word Sign (KWS) functioned as an embedded, multimodal pedagogical resource for supporting young children's mathematical thinking, particularly spatial language related to position, direction, and movement. Two complementary examples of practice were evident: intentional and deliberate use of KWS within structured activities, and spontaneous, responsive use during child-initiated play. Together, these patterns demonstrate how KWS can operate across planned and emergent moments in an ELEC, strengthening continuity between adult-led and play-based mathematics learning.

In the structured context of concert preparation, the intentional integration of KWS within a familiar sign-and-sing routine provided repeated, embodied exposure to spatial concepts. Embedding mathematical language within music and movement aligns with research emphasising the role of rhythm, gesture, and repetition in supporting young children's conceptual understanding (Shilling, 2002). Importantly, this intentional use positioned KWS not as an add-on, but as a naturalistic part of a planned program. Equally significant was the spontaneous and responsive use of KWS during block play, where children and the teacher co-constructed mathematical meaning in real time. The learning story highlights how the teacher's strategic modelling of signs, combined with an open-ended question, supported children to reason about height, and spatial relationships. Children's own gestural communication, using signs, hand movements, and embodied measurement, demonstrated emerging spatial reasoning and agency in expressing mathematical ideas. The movement between talk, sign, gesture, and action reflects how children draw on multiple semiotic resources to make sense of relational and dynamic concepts.

From a UDL perspective, these findings illustrate how KWS provided multiple means of representation and expression, supporting variability in children's communication and understanding. The teacher's responsive use of KWS reduced linguistic barriers while amplifying opportunities for engagement, persistence, and collaboration. Collectively, the observations suggest that when KWS is used both intentionally and responsively, it can enrich everyday mathematical interactions, deepen spatial reasoning, and support inclusive participation, particularly during complex, open-ended play where language, movement, and problem-solving intersect.

Conclusion

This study contributes new insights into the use of Key Word Sign (KWS) as an inclusive pedagogical strategy for supporting early mathematical learning, particularly in relation to spatial language and concepts of position and direction. The findings highlight the value of embodied approaches for strengthening mathematical understanding and underscore the importance of both intentional and deliberate, as well as spontaneous and responsive, planning approaches to using KWS in mathematics application. Although limited to a single site, the study points to the potential for greater emphasis on spatial reasoning within early mathematics programs and calls for system-level investment in professional learning and mathematics resources to support equitable access to mathematical language and learning across early childhood contexts.

Acknowledgments

Ethics approval (206182) was granted by the University of South Australia, and participants gave informed consent.

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