Hearing the signers: BSL interpreters' experiences in the mathematics classroom and implications for inclusion

Elena Nardi[1], Angeliki Stylianidou[1], Lina Kayali[1, 2]

[1]University of East Anglia, [2]University of Bristol

What may the challenges be that British Sign Language (BSL) interpreters face when assisting hard-of-hearing (HoH) and D/deaf learners in the mathematics classroom? And, if any, how can these be overcome? We report exchanges with BSL interpreters which took the form of a focused group discussion that revolved around two mathematical problems (Platonic Solids, Bridges of Königsberg) designed for a workshop aimed at teachers of mathematics as part of the CAPTeaM project. Discussion zoomed out to broader issues regarding BSL interpreters' preparedness for supporting the mathematical learning of HoH & D/deaf students. We see sharing these insights as having additional topicality within mathematics lessons and beyond, given that significant steps are finally in progress towards recognising BSL's official status across the UK.

Keywords: British Sign Language (BSL) interpretation of mathematical terms and processes; hard-of-hearing (HOH) and D/deaf learners; ableism

BSL signing in mathematics lessons

Imagine for a moment that you need to describe a mathematical problem to someone else – a colleague, students in a classroom – in another language. Let this language be one that you feel reasonably comfortable in for everyday conversations but a little less so for mathematical ones. And then, imagine that your own experiences in mathematics date back to your school days and that, since then, you have had few opportunities to have a conversation that involves several mathematical terms and processes. What may the challenges be in this occasion? And, if any, how can these be overcome?

These are some of the questions that we, as part of the team behind the **C**hallenging **A**bleist **P**erspectives on the **Tea**ching of **M**athematics (CAPTeaM) project, found ourselves asking when the project's workshops for teachers of mathematics brought us in close collaboration with British Sign Language (BSL) interpreters assisting hard-of-hearing (HoH) and D/deaf learners in the mathematics classroom (thereafter, "D/deaf" denotes both individuals with the audiological condition, hard of hearing or deaf, and those who identify with deaf culture). Working with interpreters to prepare the CAPTeaM workshop, we experienced first-hand how quintessential their role is for the inclusion of HoH & D/deaf learners in the mathematics classroom. We also had the opportunity to explore the preparedness of BSL interpreters for this role – and challenges thereof.

Here, we share insights from our exchanges with three BSL interpreters as we were preparing for a CAPTeaM workshop in which BSL interpretation was needed to convey to participating teachers – a mix of hearing and HoH & D/deaf – a series of mathematical activities and to assist with group work and plenary discussions. Our exchanges with the BSL interpreters took the form of a focused group discussion that revolved around each of the activities. Discussion regularly zoomed out to broader issues regarding their preparedness for supporting the mathematical learning of HoH & D/deaf students.

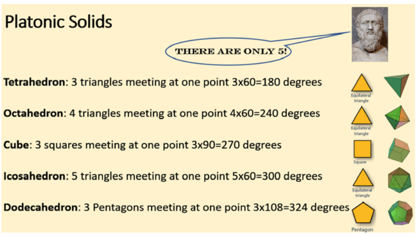
We see sharing these insights as having additional topicality within mathematics lessons and beyond, given that significant steps are – at last – in progress towards recognising BSL's official status across the UK.

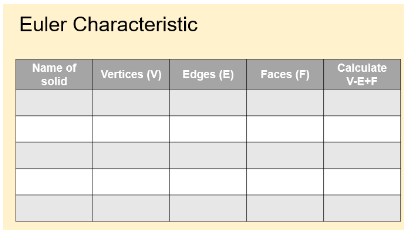
In conversation with signers: Two mathematical activities

Our conversation involved three BSL interpreters appointed for the workshop to sign the mathematical activities designed by team members of the CAPTeaM study. In this particular workshop, three faculty members and three (at the time) doctoral researchers were involved. Discussion revolved around their reflections on these preparations and challenges thereof. The focus was on two activities, one on Platonic Solids (Activity I) and another on the well-known Bridges of Königsberg Graph Theory problem (Activity II). The conversation took place in three parts: introduction to Activity I, followed by a group discussion of the interpreters' experiences in preparing to sign for this activity; introduction to Activity II, followed also by a similar discussion; and, zooming out to discussing issues germane to signing mathematics overall. We now introduce Activities I and II briefly and highlight points from the discussion about each.

Activity I (Platonic solids)

The activity included: introducing a set of definitions (polygons, regular polygons, non-regular polygons, convex polygons, concave polygons); presenting nine examples of regular polygons (equilateral triangle, square, pentagon, hexagon, heptagon, octagon, nonagon, decagon, undecagon); introducing polyhedrons, convex and concave; presenting polyhedron examples such as cube, prism, pyramids; and, presenting Platonic Solids (Figure 1). To sum up the activity, participants are asked to calculate the Euler Characteristic for the five Platonic Solids (Figure 2).





Excerpts from slides prepared for Activity I

Figure 1. List of Platonic Solids

Figure 2. Euler Characteristic table

The shift from 2D to 3D was noted by the BSL interpreters as the first challenge that signers would face in signing for Activity I. Switching from 2D shapes to 3D objects calls for moving from signing with one hand (using hand palm for 2D) to signing with both hands for 3D (we invite interested readers to consult with the collection of BSL videos demonstrating the signs used for mathematics, and all else, at the British Sign Language Dictionary). A second, and possibly dominant, challenge with Activity I was with the introduction of many terms (edge, face, vertex, polygon, polyhedron, convex, concave and so on). Our interpreters stressed that packing one single activity with so many terms was bound to be a challenge for HoH & D/deaf learners and one that could be interpreted as short of inclusivity. One question that was posed to us was about what made all these terms necessary. The conversation turned to a suggestion that was found by all as relevant to hearing and HoH & D/deaf learners alike: start with hands-on activities and build polygons and polyhedrons; then, introduce definitions as well as similarities and differences between the different shapes/objects. In other words: start with building the meaning with and for students, and then introduce the terms.

Another question that was posed to us was about the status of these terms – some of them with a sign available already, some not – in mathematics lessons as opposed to science lessons. The term "convex" was given to us as an example of a term with a different, and particular, meaning in Physics. The interpreters emphasised that signing convex and non-convex poses a problem: in sign language, concave (non-convex) "goes in", convex "goes out". They cautioned that this can be counterintuitive. This observation led to a discussion about whether a different, perhaps more "embodied", way of signing "convex" and "concave" may be more helpful (e.g. signing "convex" as a belly or conjuring up an image of a "lens"). We note that this reference to an "embodied" approach concurs with CAPTeaM's sociocultural and embodied theoretical underpinnings (Nardi et al., 2018). We see learning as participating in – and making one's own – discourses associated with mathematics. The process of making something one´s own in mathematics is shaped by the tools used to act with it – and this process includes tools of the body as well as material and semiotic artefacts.

Another example that was brought to our attention was that the interpreters' efforts to sign for "polyhedron" conveyed more directly the mathematical meaning of the term than the word itself, as signing included the process of forming a polyhedron. In Greek, "polyhedron" is a composite word ("poly", from "πολύ", for "many"; and, "hedron", from "έδρα", for "face") that coveys directly "that which has many faces". In English, unless its etymology is explained, the term can be experienced as more esoteric.

Two more issues that were brought to our attention included: the essential role that the physical presence of the five solids was likely to play; and, the positioning of the interpreter in relation to the screen where objects and terms were projected (there was a strong preference for the proximity of a laptop screen, rather than the search for information on large, main whiteboard display). Finally, Activity I conjured experiences our interpreters had in examination situations where polygon names (say "pentagon") are usually signed to students using fingerspelling (p-e-n-t-a-g-o-n), instead of a sign for a pentagon that by necessity includes a reference to the number of its sides (five) – for examination regulations regarding support for HoH & D/deaf students at the time of writing, see Joint Council for Qualifications (2021). Fingerspelling was described as an extremely tedious, slow and frustrating approach to signing, often resorted to in examinations to minimise the advantage that meaning-loaded signing carries with it. One approach that was described to us as more equitable was – at the time reported by our interpreters as part of their experience in a Scottish examination situation – where a single BSL interpreter signs exam questions (on video) and that this video is then shared with all HoH & D/deaf examinees in different schools. We return to this towards the end of this paper.

Activity II (Bridges of Königsberg)

The well-known Bridges of Königsberg Graph Theory problem (Figure 3) asks: can you take a walk through the town, visiting each part of the town (the island and the two mainland parts), crossing each of the seven bridges only once and ending your walk at your starting point?

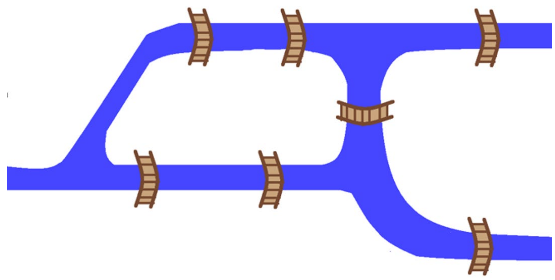


Figure 3. Excerpt from slides prepared for Activity II.

The mathematical terms that Activity II aims to introduce are: vertex, edge, graph, path, length of path, closed path, degree of a vertex, tour and Euler tour.

Our interpreters stated that these terms were difficult to sign. For example, to them, "degree" was associated with a measurement of temperature or angle. In Graph Theory, however, "degree of a vertex" denotes the number of edges connecting a vertex. "edge" was similarly problematic. Our interpreters alerted us then to a significant challenge: they did not know what these mathematical terms mean, especially in a Graph Theory context, and therefore interpreting these in BSL involved first becoming familiar with the meaning of these terms (in the context of a lesson, for example, by looking for these meanings on a board, within lesson materials etc.) and then producing either the official BSL sign for a particular term or – in the absence of a BSL sign for the term – a reconstruction of the term's meaning.

"graph" was brought to our attention as an example: its sign involves two moves: (1) showing the (x, y) system of coordinates with thumb and index finger of one hand positioned in a right angle (Figure 4a); and, then (2) scribbling a graph with the index finger of the other hand starting from within the area defined by the two sides of the right angle (Figure 4b).

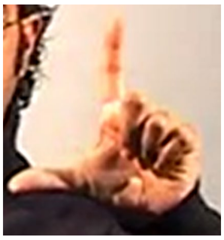


Figure 4a. Move 1 of signing "graph" in BSL: the axes.

Figure 4b. Move 2 of signing "graph" in BSL: the curve.

However, the meaning of the term "graph" in Graph Theory – a structure used to model pairwise relations between objects made up of vertices connected by edges – is different to the meaning of graph as image of a function curve. Our interpreters debated whether signing a different, more general term such as "diagram" was likely to be less misleading for learners. The stark realisation that a term used in one mathematical context – and which has an established BSL sign derived from the specificities of this context – has a different meaning in other contexts propelled our conversation beyond the challenges posed for our BSL interpreters by Activity II and into the territory of their mathematical preparedness for signing in these other contexts.

We see the urgent testimonials of the BSL interpreters in our conversation as aligning closely with the frustration expressed by organisations such as the National Sensory Impairment Partnership and the National Deaf Children's Society about the ongoing worsening of exam results for HoH & D/deaf students - for example, see NDCS (2021). A key concern that was posed to us was the far from ideal ways in which HoH & D/deaf students' needs are decided by examination boards and how little involvement HoH & D/deaf communities have in these decisions. The British Sign Language (BSL) Act 2022 promises to do better on this front. Preparations for the adjustments needed during exams and exam paper modifications are a responsibility that lies with the Joint Council for Qualifications (JCQ) and examination boards – and with negligible allowances for input from schools, the very institutions that tend to know each learner's needs better. Bundling the broad spectrum of HoH & D/deaf students' needs under the single umbrella term "deaf" often obscures the range of, say, language-related issues these learners may face. These issues may include a language delay or that BSL is actually a learner's first language. For example, when BSL is a learner's first language, or, as one of our BSL interpreters put it, "the language of the heart" – this is "[y]our first language, your concepts of life from when you were small, whatever that may be. You have those in your head and it's reaching of deaf students' heart so they can engage." – resorting to aforementioned fingerspelling of mathematical terms can be a far from ideal approach.

Challenges and ways forward

Whether signing of mathematical terms and processes for which BSL signs already exist or searching for ways to sign mathematical terms for which BSL signs do not already exist (or are at the moment covered by more generic terms, such as "square" signed in a way that is quite similar to signing "polygon"), the three BSL interpreters who shared their experiences with us asked for more opportunities to develop the quintessentially visual elements of signing. To do so, they noted, their mathematical preparedness for the meanings that terms have in the different contexts of mathematics (algebra, geometry, calculus, statistics, Graph Theory and so on) needs substantial support. As one put it, "sign language is all about visual placement." And: "With [HoH & D/deaf] students it is visual, everything is visual. […] it is finding a way to teach that with visual examples that they can relate to". Confronted with obscure terms – or terms used suddenly in unfamiliar mathematical territories – our BSL interpreters stressed that the work they were asked to do in relation to Activities I and II "wasn't even maths, was it? It was just words". And, as in the "building a meaning for a polygon through making it" proposition that emerged during the discussion of Activity I, our BSL interpreters noted that "to see [a polygon] being put together, as a complete novice […] is helping me": "to see [the polygon] coming together, the words suddenly make sense".

"Translation is in the hand…"

In closing, we return to the observation we made earlier about how often BSL signs for mathematical terms convey quite robustly the meaning of these terms (see earlier example of "pentagon"; other examples mentioned in our conversation included "nets"). We wonder what learning benefits for all – hearing and HoH & D/deaf students alike – may lie in engaging with BSL signing for mathematics. A member of our team (Stylianidou, 2021) makes the case of mutual benefits for all learners in class in the case of visually impaired learners in inclusive primary mathematics lessons..If an aspiration for HoH & D/deaf student inclusion in mathematics lessons is of groups of students working together, happily and productively, could we see the negotiation of mathematical meaning conveyed in BSL signs as part of this collective effort that is likely to be of benefit to all? Fingerspelling "n-e-t", by the way, is most likely to take the potency of this proposition away! Benefitting from what one of our BSL interpreters described as "Translation is in the hand…" is putting all this potency back in!

BSL signs are forms of communication that may reveal, and help construct, mathematical meaning. This is a fascinating way forward that can generate rich mathematical meanings for all. We are heartened by growing bodies of work exactly in this area: Tabak (2014), for example, writes about this potency and proposes (Tabak, 2016) a model for the development of signs in higher mathematics. Schaefer et al. (2021) write about facilitating HoH & D/deaf students' understanding and working with word problems through the use of sign language videos.

We learned much from this brief – albeit utterly illuminating – opportunity to converse with the three BSL professionals who shared their experiences with us, directed our critique towards the specific needs of their profession and indicated ways in which BSL interpreting in mathematics lessons can become a means to a wonderful end: not only steer clear of the tedium and ineffectiveness of fingerspelling but become a platform for productive and enjoyable co-construction of mathematical meaning for all – hearing and HoH & D/deaf learners alike.

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