Mathematical discourses of a teacher and a visually impaired pupil on number sequences: Divergence, convergence or both?

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Research on the inclusion of visually impaired (VI) pupils in mainstream classrooms is underdeveloped in mathematics education. This paper investigates mathematical discourses of a teacher and a VI pupil in a classroom episode on number sequences. We see that, while the teacher considers the pupil's enthusiastically demonstrated mathematical contribution which differs from the institutional one, she draws on it to guide him in responding within the institutional mathematical discourse. We then see the pupil responding within the teacher's expectations but less enthusiastically. We explore the teacher's reaction in terms of whether it evidences valuing of the pupil's initial mathematical contribution and whether it is potentially excluding. We propose an alternative, more explicitly inclusive way forward in which the teacher can play along with non-prevalent mathematical contributions and bring these also to the whole class, to the benefit of all.

Keywords: Discourse, inclusion, VI pupils.

Introduction

Inclusive education has been an issue of international consideration especially since the Convention on the Rights of Persons with Disabilities (CRPD) (United Nations, 2006). According to Article 24 of the CRPD, the signatory countries are committed to ensuring the right of persons with disabilities to education within an inclusive education system. Educational benefits from inclusive education are not limited to persons with disabilities though: "[T]here are educational benefits for all children inherent in providing inclusive education" (UNICEF, 2012, p. 11). But is this good intent implemented in the classroom? And if so, how – and, how is it experienced by staff and pupils?

In the study we draw from in this paper – part of the first author's doctoral thesis – we focus on the inclusion of VI pupils in mathematics lessons. We see inclusive education as occurring when the VI pupils are invited to participate in a lesson activity on an equal basis with everyone else in class, albeit not necessarily with the same sensory, material and semiotic tools. Apart from equitable participation, we consider equitable value as an equally important element of inclusive education. With the latter, we denote the value attributed to VI pupils, even in those contributions which differ from the prevalent, institutional ones, potentially as a result of the different tools through which VI pupils may construct and convey mathematical meaning. Reference to participation and value as contributors to inclusive education is present in international documents (e.g. United Nations, 2006) as well as in research studies (e.g. Nardi, Healy, Biza, & Fernandes, 2018). We consider equitable participation and equitable value as interrelated elements of inclusive education: our study's rationale is that one element exclusive of the other does not suffice for implementation of inclusive education. Our discussion of the data we present in this paper evidences the necessity of both elements for what we call "inclusive education".

In this paper, we first discuss key developments in the inclusion of VI pupils in mathematics classrooms. We then zoom in on the study's focus and research questions and present the study's theoretical framework and methodology. Finally, we sample from the study's data and analysis with an episode from a Year 1 (Y1) class.

Literature review and theoretical framework

A limited number of studies have been conducted in the area of inclusion of VI pupils in mathematics classrooms. The existing literature focuses mainly on the following themes: VI pupils' experiences in mainstream mathematics classrooms (e.g. Bayram, Corlu, Aydın, Ortaçtepe, & Alapala, 2015); VI pupils' forms of accessing, expressing mathematics and development of inclusive teaching strategies (e.g. Nardi et al., 2018); and, design of inclusive mathematics teaching and learning materials to be used by VI and sighted pupils (e.g. Leuders, 2016). While the existing literature has certainly set the foundations towards more inclusive mathematics classrooms, research studies that investigate how VI pupils are included in the classroom are sparse. We argue that an investigation of VI pupils' inclusion in mainstream mathematics classrooms combined with the existing foundations for such an inclusion can lead to even more inclusive mathematics classrooms. As our study explores (e.g. in the episode sampled in this paper), there may be significant gaps between inclusive education policy and practice: while appropriate inclusive education aspirations may appear in international and national policy documents, institutional, curricular and attitudinal constraints may lead to these gaps. Our study aims to investigate these and eventually contribute towards their reduction.

Our study has two phases and investigates: (a) how inclusion and disability are constructed in the discourses of teaching staff and pupils in mainstream mathematics classrooms (both phases); (b) how collaboratively designed mathematics lessons impact upon teaching staff's and pupils' discourses on inclusion and disability (Phase 2). We endorse a sociocultural theoretical framework that draws upon: Vygotskian sociocultural theory of learning (Vygotskii, 1978); Sfard's discursive perspective, known as the theory of commognition (Sfard, 2007); the social model of disability (Oliver, 2009); and, the theory of embodied cognition (Gallese & Lakoff, 2005). We discuss such use briefly in Stylianidou and Nardi (2018) and exemplify this use in this paper.

In the episode we present in this paper, we focus on the discursive activity of a teacher and a VI pupil, in interaction concerning number sequences. Our Vygotskian influence is evidenced in our focus on: the semiotic and sensory tools used by the two interlocutors in the setting of the school classroom; and, the mathematical meaning each interlocutor conveys as a result of using the particular tools. We show how particular elements from Sfard's discursive perspective – word use and visual mediators – are played out in the mathematical discourse of each interlocutor and we examine a case of commognitive conflict (Sfard, 2007) arising as a result of the teacher's and the pupil's different, incommensurable discourses. The visual mediators in the particular episode constitute the gestures, made by both the teacher and the pupil. Apart from speech, the gestures act too as a vital tool for mathematical communication and the construction, and conveying, of mathematical meaning. This role of gestures makes the theory of embodied cognition (Gallese & Lakoff, 2005) pertinent in our analysis of the episode.

In what follows, we present the study's context, participants and methods. We then sample from the data with an episode from a Y1 lesson on number sequences. We conclude with implications that this episode has for our ongoing analyses, particularly those included in the first author's doctoral thesis.

Methodology: the context, participants and methods of the study

Data collection was conducted in four UK mainstream primary mathematics classrooms (Y1, Y3 and two Y5 classes; pupils' ages: 6-10). The VI pupils' presence and the willingness of teaching staff and pupils to participate in the study constituted our criteria for the selection of the classrooms. We collected data after securing ethical approval by our institution's Research Ethics Committee and ensuring participant anonymity, confidentiality and right to withdraw from the study.

We collected data through observations of 29 mathematics lessons (33.5 hours in total); individual interviews with 5 class teachers (6 interviews, 2 hours and 10 minutes in total); individual interviews with 4 teaching assistants (6 interviews, 2 hours and 15 minutes in total); focussed-group interviews with 35 pupils (16 interviews, 2 hours in total); 2 ten-minute individual interviews with one pupil; written transcripts of the teaching staff's contributions in the design of the three Phase 2 lessons; photographs of the pupils' work in the three Phase 2 classes; and, pupils' evaluation forms of the Phase 2 lesson in two classes. During observations, written notes were kept in all lessons. 21 lessons were audio-recorded and 14 lessons were also video-recorded. All interviews were audio-recorded, except four, following interviewee requests. For these, written notes were kept instead.

Data collection for Phase 1 was completed in March 2018 and for Phase 2 in July 2018. Data analysis is ongoing. While a major rationale for Phase 2 is to explore the impact of the co-designed mathematics lessons upon the participating teaching staff and pupils, we note that the Phase 2 episode we have selected to discuss in this paper does not stress the elements of co-design and its impact upon the participants. Instead, our emphasis here is on the mathematical discourses of a teacher and a VI pupil in a classroom incident in which we discern a genuine mathematical contribution by the pupil that diverges from the one expected by the teacher. We discuss the different mathematical discourses of the teacher and the pupil and explore the challenges of implementing inclusion. We first present a factual account – and then a preliminary analysis – of the episode. We conclude with a discussion of the episode in the context of the entire study.

A Y1 episode

A factual account of the episode

The episode is from a lesson on number sequences in a Y1 class. Ned is the VI pupil of this class and has severe, congenital visual impairment in both his eyes. The class has two general teaching assistants who support pupils that need help at particular instances and their role does not focus on supporting the VI pupil specifically. The class was asked to find the next number in a number sequence, which was on a worksheet that each pupil had in front of them. The number sequence was 8 10 12 14 16. The following dialogue occurs between the teacher and Ned:

1 Teacher: Is it increasing or decreasing?

2 Ned, *happily*: Creasing. *Ned puts his hand straight up, doing a similar gesture to the one the teacher had done when, earlier, she explained "increase".*

3	Teacher:	Increasing or decreasing? "Increase" means it gets bigger, or is it getting smaller. *Whilst saying "bigger", the teacher does a similar gesture to the one Ned had just done. Whilst saying "smaller", she does a gesture, too, pointing down.*
4	Ned:	Increasing. *He says this with less enthusiasm than before and without doing any gestures this time.*
5	Teacher:	Yeah. You are right.

A preliminary analytical account of the episode

Ned's reaction to the teacher's question (2)

Ned responds to the teacher's question in (1) by resorting to verbal and gestural discourse. His word "creasing" may suggest that he does not recall the difference in the meanings of the words "increasing" and "decreasing". Ned uses the root word, "crease"[1], of both verbs to show, possibly, that he refers to one of the two verbs, although it is unclear from his speech per se whether he means "increasing" or "decreasing", thus whether he answers the teacher's question correctly.

His gesture, which accompanies his speech, makes it clear that Ned refers to the term "increasing". Here, the gesture is vital in Ned's conveying the mathematical meaning he has constructed of what an increasing sequence of numbers is. Ned's re-enacting of the teacher's gesture for the term "increasing" resonates with the theory of embodied cognition, according to which concepts are embodied (Gallese & Lakoff, 2005): "the *sensory-motor* system can characterise a sensory-motor *concept*, not just an action or a perception, but a *concept* with all that that requires" (p. 468).

As mentioned above, Ned's speech alone does not suffice for our understanding as to whether Ned refers to "increasing" or "decreasing". Similarly, we can argue that his gesture alone does not suffice either for our understanding of Ned's mathematical expression. His gesture, isolated from his speech, may signify a variety of things, one of which is the term "increasing". The combination of Ned's speech and gesture, though, strengthens our speculation that Ned refers to the term "increasing".

The contribution of both speech and gesture in Ned's mathematical expression, and in our interpretation of it, demonstrates how merging Vygotskian (1978) sociocultural theory of learning and the theory of embodied cognition (Gallese & Lakoff, 2005) is important in our analysis. Take, for example, Ned's response in (2) where we need both his speech and his gesture to grasp how he conveys what he means by "increasing". Both theories – speech as the vital tool for mathematical meaning making and expression (Vygotskii, 1978) and the embodied nature of concepts (Gallese & Lakoff, 2005) – are combined to help us analyse Ned's response in (2). One theory, deployed exclusively, would not suffice for our interpretation of Ned's response.

In (2), we mention the adverb "happily". With our use of an adverb that indicates emotion, we aim to show that we are interested not only in what our participants utter but also in how they feel as they do so. The 'how' part may be expressed with tone of voice, facial expressions and gestures and it provides us with information that frequently adds to, and further illustrates, the 'what' part. Ned's

[1] "crease" originates from the latin word "crescere" ["grow", Oxford English Dictionary (http://www.oed.com/)].

happiness is evidenced in his tone of voice and facial expression – when he says "creasing" – as well as in his gesture – we see excitement in the way he gestures. We attribute his happiness to a sense of fulfilment he may derive from the correctness of his answer. Later, we see that this correctness is cast into doubt, if not disapproved, by the teacher. Our exploration of the relation between emotion and cognition resonates with discussions in the literature of the relation among mathematical achievement, enjoyment and self-efficacy in mathematics. For example, we agree with Goldin, Epstein, Schorr, & Warner (2011, p. 553) that "affect, cognition and motivation interact to influence students' mathematical engagement in classroom social environments". Another reason why we have included a reference to Ned's emotion is to later compare this emotion to that in his second answer, in (4), and associate the fluctuation between the two with the teacher's reactions in the two cases.

Teacher's reaction to Ned's response (3)

The teacher does not explicitly react to Ned's response, either by approving it or by disapproving it. We see in her response, though, implicit dissatisfaction: Ned's answer does not include any of the two terms that the teacher expects to hear. Hence, the teacher repeats her previous question, albeit with a different sentence and tone of voice.

Her omission of the part "Is it", which is in (1), and her direct use of the verbs separated with "or" show her emphasis on these two verbs, which she seems to expect from her interlocutor too. She pronounces the underlined prefixes "in" and "de" in (3) in a different tone of voice. This may indicate some concern about Ned's wording, which does not include any of the two prefixes.

We interpret the teacher's explanation of each of the two terms in (3) as showing her interpretation that Ned may not recall the meaning of the two terms. As with her question, her explanations suggest, too, her emphasis on the two mathematical words, which she expects to hear from Ned.

While the teacher's mathematical discourse is mostly verbal-institutional and the teacher expects such kind of discourse from Ned, too, in this part of the episode, the teacher accompanies her speech with gestures. Thus, she creates a verbal-institutional and gestural mathematical discourse, with each of its components – speech and gesture – serving the same purpose: that of explaining the meaning of the key terms. We interpret the teacher's use of a similar gesture to Ned's one as a manifestation of "attuning" (in the sense of Nardi et al., 2018) to the gestural part of her pupil's mathematical contribution and of her approval of gesturing as a form of mathematical expression, albeit not independently from 'approved' speech. Through her gesture, we see that the teacher considers Ned's gesture, too, but – alongside speech – she draws on it to guide him in responding within the mathematical discourse which she, and the educational institution she represents too, approves. Therefore, the teacher seems to be concerned about Ned's wording but she seems to partially approve his gesture. Her expectation is of an answer within the verbal discourse aligned with institutional (the National Curriculum's) standards. The teacher's attuning to Ned's gesture resonates with the first camp of participants in (Nardi et al., 2018, p. 157): that of using the VI pupil's contribution to focus on a more conventional contribution.

Drawing upon Sfard's (2007) theory of commognition, we see evidence of commognitive conflict in the exchange between the teacher and Ned. We define commognitive conflict as the situation occurring when seemingly conflicting narratives originate in different, incommensurable discourses

(Sfard, 2007). We see the different mathematical discourses of two interlocutors, both of whom aim to convey their mathematical meaning of an increasing sequence of numbers. We see the commognitive conflict in the teacher's non-playing by the meta-discursive rules set by Ned: she considers Ned's speech in isolation from his gesture and vice versa. Indeed, as discussed in (1), Ned's speech isolated from his gesture – and Ned's gesture isolated from his speech – do not suffice for conveying the meaning he seems to have constructed of an increasing number sequence. We see that the commognitive conflict arose as a result of the teacher's consideration of Ned's mathematical discourse as consisting of two separate, unrelated elements: speech and gesture. We argue that, had the teacher considered Ned's verbal-gestural discourse as an entity, commognitive conflict might have been avoided: instead, an acknowledgement of two different, but equally acceptable, mathematical discourses might have occurred.

Ned's reaction to the teacher's response on his answer (4)

We then see that Ned changes communicational mode from verbal-non-institutional – which was seen as problematic by the teacher (3) – and gestural – which was partially accepted by the teacher (3) – to verbal-institutional – which, as he knows from (3), is accepted by the teacher. Here, Ned responds to the teacher's question by playing by the meta-discursive rules set by the teacher, which, as discussed in (3), puts the emphasis on endorsed forms of speech. However, his shift in communicational mode does not seem to be a pleasant experience. His tone of voice and his facial expression evidence this reduced enthusiasm. This raises issues on how included Ned feels his mathematical contribution in (2) is. We see that in (3) the teacher's non-developing of Ned's mathematical contribution in its own right – the camp of teachers' developing of VI pupils' contributions in their own right is the second camp discussed by Nardi et al. (2018, p. 158) – is excluding. The teacher restricts Ned to responding within the boundaries of an institutionally endorsed mathematical discourse and this limitation seems to dissatisfy Ned. Drawing upon the relation between affect and cognition, we associate Ned's apparently reduced enthusiasm with the teacher's concern over his initial contribution and her expectation of his responding in one, particular way. Ned's non-gesturing here may be attributed to several reasons. It may be attributed to the non-contribution of a gesture to his conveying of his mathematical construction of an increasing number sequence, since his use of speech suffices as an answer to the teacher's question, unlike in (2). It may also be attributed to Ned's interpretation from (3) that gesturing is not a necessary, or even appropriate, form of mathematical communication.

Teacher's reaction to Ned's response (5)

We then see that the teacher clearly approves Ned's response: his response in (4) resonates with the teacher's expectations, in which speech seems to dominate over gestures.

Discussion of the episode in the context of the entire study

This episode is selected to evidence mathematical discourses of a teacher and a VI pupil in a mainstream classroom and discusses the extent to which mathematical communication is achieved between the two interlocutors.

Zooming out to the entire study, we see that, despite the invitation towards VI pupils to participate in the mathematics lesson on an equal basis with their peers, their mathematical contributions – which may differ from the ones expected by the teacher – may not always be as valued as they could. In other words, we see evidence of equitable participation but not equitable value in the mathematics classroom. We see this discrepancy as a hurdle to implementing inclusion. We are unsure whether this discrepancy arises as a result of undervaluing of the mathematical discourses of VI pupils, as a result of a persistent adherence to the institutional mathematical discourse, as a result of both and/or other influences. In the episode we discuss here, though, we do not consider the teacher's concern with the VI pupil's initial mathematical contribution as ableist[2] and we note that there was hardly any evidence of ableism in the observation and interview data from this teacher. We attribute her concern to this contribution's divergence from the prevalent one and we thus stress that her concern in similar cases is likely to occur with every pupil, not just with a VI one.

In the episode, we see the reported interaction as associated – but possibly not limited – to visual impairment. We argue that the pupil's contribution may be seen through existing findings on visual impairment: for example, VI pupils use their hands to construct and convey mathematical meaning (Nardi et al., 2018). We also argue that the teacher's response in (3) was specific to the pupil's genuine mathematical contribution.

Regardless of the reason attributed to the teacher's concern with Ned's mathematical contribution, we set the following questions. Do we, as educators, need to accept only those mathematical contributions that resonate with the institutional ones? Or, do we need to reflect upon the different contributions of our pupils, discern whether they are mathematically valid too and act accordingly to include them in the lesson? Without ignoring the necessity for the pupils' familiarisation with, and endorsement of, established mathematical discourse, we propose that we should heed the reactions of our pupils, even in cases when we, either explicitly or implicitly, have concerns about mathematical contributions which differ from the institutional ones: different pupils construct different meanings of mathematics. This is how we see inclusive education implemented in the classroom: through equitable participation and equitable value. We argue that our valuing, attuning and integrating of pupils' non-prevalent mathematical contributions into lessons may not only encourage participation in the mathematics lesson but may also benefit all pupils in class, who may experience mathematics from a different, and potentially enriching, point of view.

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[2] Ableism is defined as "a network of beliefs, processes and practices that produce a particular kind of self and body (the corporeal standard) that is projected as the perfect, species-typical and therefore essential and fully human. Disability, then, is cast as a diminished state of being human" (Campbell, 2001, p. 44).

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