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Overcoming Obstacles for the Inclusion of Visually Impaired Learners through Teacher–Researcher Collaborative Design and Implementation

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Abstract: Teacher preparation to address the needs of disabled learners in mainstream mathematics classrooms is quintessential for the implementation of the inclusive educational policies that governments are often committed to. To identify teacher preparation needs, we draw on data and analyses from the doctoral study of the first author, who endorsed sociocultural and embodied perspectives in an investigation—first exploratory, then interventional—of visually impaired (VI) learners' experiences and their teachers' inclusion discourses. Here, we focus on the intertwined contributions of physical and digital resources in the mathematical learning experiences of VI pupils, as these resources co-existed simultaneously in the observed mathematics lessons. We first summarise findings from the exploratory phase that highlighted inclusion issues related to resource use in the mathematics classroom. We then offer a critical account of the circumstantial and systemic obstacles that impeded the successful intertwinement of digital and physical resources and discuss teacher–researcher collaborative design and implementation of classroom tasks (auditory, tactile) in the intervention phase. We conclude by making the case that well-meaning individual teacher–researcher collaboration is a necessary condition for such interventions to succeed but not a sufficient condition for these interventions to be scaled up and have longevity.

Keywords: inclusion; disability; mathematics teacher education; mainstream classrooms; visually impaired learners; tactile and auditory mathematical tasks

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1. Introduction and Literature Review

There is recognition, in principle, of the importance of training teachers to address SEND learners' needs in international and national policy documents. Inclusive education needs to be implemented, not only because it promotes disabled people's rights to education [1], but also because it offers social and educational benefits to all learners [2]. In terms of social benefits, inclusive education makes disabled learners less stigmatised and more socially included while it also enriches non-disabled learners with tolerance, acceptance of difference, and respect for diversity [2]. In terms of educational benefits, inclusive education gives disabled learners access to a comprehensive curriculum, and it also leads to higher achievement than that found in segregated settings [2]. Simultaneously, inclusive education provides educational benefits to all learners through the changes that it brings in educational planning, implementation, and evaluation.

In England, Initial Teacher Education (ITE) policy concerning the inclusion of disabled learners includes statements such as: "trainee teachers must achieve professional standards before they can be awarded qualified teacher status. The standards ensure that teachers are able to help all pupils, including disabled pupils, to achieve their full potential" ([3] p. 73). More specifically, the policy states that "[t]eachers must learn to vary their teaching to meet the needs of all pupils, including those with SEN" ([3] p. 73) and that "[t]eachers must understand how pupils' learning can be affected by their physical, intellectual, linguistic, social, cultural and emotional development" ([3] p. 73). Such statements indicate that it is the responsibility of trainee teachers to learn how to teach disabled pupils so that the latter can achieve their full potential. Implicit in these statements is the role of the ITE programmes that provide teachers with the aforementioned training. Yet, these statements contain somewhat implicit references to this role, lack specificity and are aspirational rather than pragmatic. For example, there are scant references to the amounts of time needed for the aforementioned training.

This remains evident in recent policy documents in which the overall principles remain intact: ("the UK Government's vision for disabled children and young people is the same as for everyone else; to enable them to fulfil their potential in education, and go on to live happy and fulfilled lives.", [4] para. 12; "To ensure consistency across England our focus is improving the quality of Education, Health and Care plans (for those with complex needs) and of SEND support in schools and colleges.", [4] para. 13). However, there are very few statements that relate to Initial Teacher Training and Disability. Here are two examples of such statements.

The first statement prescribes the importance of training all teachers in adaptive teaching:

"Adaptive teaching is an important area in the CCF [Core Content Framework]. Alongside important content relating to the most effective approaches to adapting teaching in response to pupil needs, it sets out some specific content relating to knowledge and experience that all trainees must acquire relating specifically to pupils with Special Educational Needs and Disabilities (SEND). It is critical that all teachers begin their teaching career with adequate basic knowledge and expertise in this area, and all ITT curriculums, whatever the context, must set out specific content relating to SEND which trainees will learn and put into practice during training. As with all areas of the trainee curriculum, learning about SEND must be planned and specific, and there must be an assurance that all trainees have covered and learnt what has been planned." ([5] p. 13)

The second statement stresses the importance of access to training for those choosing to specialize in SEND:

". . . alongside the universal SEND knowledge and expertise which all trainees should possess, there is scope for those preparing to specialise in SEND, either in specialist provision or in mainstream schools, to be able to access a specialist training curriculum that focuses in more depth on SEND-relevant knowledge and expertise. Such a training curriculum, which must be rigorously evidence based, should equally meet the expectations for detailed and specific planning, as should the expectations for school placement and mentoring, to ensure that the curriculum is delivered to trainees with the same standard of quality and consistency that we envisage elsewhere." ([5] p. 13-14)

Our work aims to address the tension between intended and implemented policy and identify what teachers need in order to build inclusive mathematics classrooms. Research in this area indicates that there is limited teacher training (e.g., [6–9]). Implicit ableist narratives and a prioritising of the needs of a perceived "normal" student may underlie limitations in teacher training [10]. Ableism is "the 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" ([11] p. 44) and holds a perspective on disability "as a diminished state of being human" [11]. The study that our paper draws upon [12] builds on this research. Our study aims to substantiate the benefits to all learners that are aspired to in international legislation as outcomes from the implementation of inclusive education. Such substantiation aims to highlight the significance of ITE around inclusion in England and beyond. Hence the focus of this paper is on investigating what teachers need in order to include VI pupils in their mathematics lessons and on how such inclusion can be of benefit to everyone in the class.

This study was divided into the following sections: the sociocultural and embodied theoretical underpinnings of our study [12] (2) are presented; the research design, context and participants of the study, methods of data collection and analysis are introduced (3); inclusion and resource issues in mathematics teacher education (MTE), circumstantial and systemic obstacles in implementing intertwined resources for inclusion and teacher–researcher collaborative design and implementation are presented (4); and the study concludes by discussing the implications for teacher education towards inclusive mathematics classrooms (5).

2. Theoretical Framework

The theoretical underpinnings of our study are sociocultural and include the social model of disability [13] and the Vygotskian sociocultural theory of learning, with a particular emphasis on the notion of mediation [14,15]. A pertinent role in the study's theoretical framework is also played by the theory of embodied cognition [16].

2.1. Influences from the Social Model of Disability

Our work endorses a social model of disability, according to which disability is socially constructed [13]. The social model considers disability as a problem imposed by society, which excludes people's full participation in social, educational, cultural, and other activities due to their impairments [13,17–19]. LoBianco and Sheppard-Jones argue that disability can be far less of an impediment when societies remove the barriers that disable individuals [20]. The social model of disability is associated with an inclusive approach to the education of disabled learners. According to this approach, it is the school that needs to transform its culture, policies, and practices in order to accommodate every individual's needs [2]. The social model of disability underpins the Convention on the Rights of Persons with Disabilities (CRPD) [1]. This convention considers that "disability is an evolving concept and [. . .] results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others" ([1] p. 1). Drawing upon Oliver's social model of disability [13], our study—which focuses on the inclusion of VI pupils—uses the constructs of "enabling" and "disabling". We use the terms "enabling"/"disabling" when a sighted member acts in a way that meets/does not meet the VI pupil's perceptual needs in a mathematics lesson. We define perceptual needs as the needs that relate to the pupil's accessibility to the mathematics lesson.

2.2. Influences from the Vygotskian Sociocultural Theory of Learning

The study's definition of "mathematical learning" is embedded in the Vygotskian sociocultural theory of learning [14]. In particular, we see mathematical learning as a social process which is characterised by the use of semiotic, material, and sensory tools that all comprise the culturally developed subject of Mathematics. While Vygotsky [14,15] explicitly considers semiotic and material tools as forming Mathematics, in his earlier formulations of the notion of mediation, which occurred while he was working with disabled learners, he implicitly considered parts of the body as sensory tools too, which—much as semiotic and material tools do—impact upon the individual's cognitive activity. This implicit consideration emanates from the tenet that body parts can be thought of as "instruments" used to sense the world: "the eye, like the ear, is an instrument that can be substituted by another" ([21] p. 83). Vygotsky's [15] attribution of the role of a psychological tool to elements of the body constitutes a strong allusion to the embodied nature of the human intellect. However, while the embodied nature of cognition is clear in Vygotsky's [15] works, Vygotsky was primarily interested in the sociocultural characteristics of said tools.

Vygotsky's ideas about knowledge mediation have their roots in his experimental work with disabled learners [15]. Vygotsky acknowledged that the language of a culture tends to be designed for the able-bodied. This implies that language may not be accessible to people who lack, or have limited access to, a sensory channel. He suggested that, instead of focusing on quantitative differences in achievements between disabled and non-disabled learners, a qualitative perspective can be enlightening. For Vygotsky, the inclusion of disabled learners in social and cultural activities can be fulfilled in the identification of ways to substitute the traditional mediational means with others, which are more suitable to the specific ways in which disabled learners interact with the rest of the world. For example, in the case of VI learners, Vygotsky posited that their inclusion could be achieved through substituting their eyes with another tool. As with the inclusion of any other tool in an activity, this substitution can be expected to cause a restructuring of the cognitive activity of the VI individual [15]:

> *"The positive particularity of a child with a disability is created not by the failure of one or other function observed in a normal child but by the new structures which result from this absence [. . .] The blind or deaf child can achieve the same level of development as the normal child, but through a different mode, a distinct path, by other means. And for the pedagogue, it is particularly important to know the uniqueness of the path along with the child should be led".* ([21] p. 17)

Therefore, Vygotsky considered disabled learners as different but not deficient. He focused on what these learners can do rather than on what they cannot do.

This understanding of inclusion and disability resonates with the understanding of inclusion as evident in today's international legislation (for example, [1,2,22]). In particular, Vygotsky [15] acknowledges the importance of designing education systems suitable for the able-bodied and disabled learners alike.

In the study that our paper draws on [12], we examine how the aforementioned sensory, semiotic, and material tools mediate the mathematical learning of VI pupils and consequently affect the inclusion and enabling of these pupils in the mathematics classroom [9,23,24]. Closely aligned with our investigation of the experiences of VI pupils is our focus on their teachers' preparedness to fulfil those learners' needs as well as on how the uses of said mediating tools are, or can be, beneficial to all learners in class.

2.3. Influences from Gallese and Lakoff's Theory of Embodied Cognition

While the theory of embodied cognition is not used by Gallese and Lakoff specifically for disabled learners, its tenets imply that disability is not a direct implication of an individual's physical impairment. This is extrapolated from Gallese's [25] and Gallese and Lakoff's [16] understanding of cognition: cognition is embodied, and understanding is multimodal.

The combination of these two tenets from the theory of embodied cognition [16] implies that a bodily impairment does not equate to disability: a sensory organ is one of the multiple modalities through which knowledge is constructed. Therefore, a limited function—or a non-function—of this organ does not by itself stop the individual from such construction, as there are other perceptual modalities to be utilised. In the theory of embodied cognition [16], what may make an impairment a disability would be a lack in the provision of multimodal activities to an impaired individual. Indeed, as understanding is multimodal, if a learning experience is reliant on the activation of a sensory channel with limited or no function, then the individual will be disabled. Therefore, within the theory of embodied cognition [16], disability can be seen as socially constructed. Implicit as well is the assumption that, as cognition is embodied, a necessary element of inclusion is the provision of opportunities that allow the impaired individual to construct knowledge. Therefore, the theory of embodied cognition seems to resonate with the understanding of inclusion in current international legislation (for example, [1,2,22]).

In the study that our paper draws on [12], we are particularly attentive to the multimodal elements in knowledge construction that the theory of embodied cognition draws attention to. We see cognition as both an intrapersonal and interpersonal process [25]: what we know and do is a result of our constant interactions with the world via our bodies and our brains. In tandem with our Vygotskian view of teaching as an intrapersonal and interpersonal process of engaging learners in discourses associated with the sociocultural activity known as mathematics, from an embodied viewpoint, the interpersonal elements of cognition are particularly important as they occur in the context of actions, emotions, and senses of, and with, others.

In the light of the theoretical influences from the sociocultural theory, embodied cognition and the social model of disability outlined so far, the research questions that our paper aims to explore are:

Research Question 1: What teacher preparation needs should teacher education programmes address, especially in relation to how teachers use resources in their lessons towards inclusive mathematics lessons?

Research Question 2: How does teacher–researcher collaborative design and implementation of inclusive classroom activities contribute to the benefit of everyone in class, disabled and able-bodied alike (in our case: VI and sighted learners)?

We see Research Question 1 as directly related to MTE programmes and Research Question 2 as addressing the need for on-the-ground, and ongoing, teacher engagement—and continuing professional development—with the fast-rising developments in the area of inclusive mathematics education research. We also note that our study sets out from the longstanding assumption within the participatory action research paradigm [26] that there exist vital benefits for research in teacher–researcher collaborations in shaping urgent research agendas as voiced by key stakeholders (learners and teachers) and in trialling applicable solutions to problems.

We now introduce the research design, context, and participants of the study that our paper draws on. We also outline the study's methods of data collection and analysis.

3. Methodology

3.1. The Research Design of the Study

The study [12] upon which this paper draws is the doctoral study of the first author and was supervised by the second author. The study investigated inclusion and disability in the discourses of teaching staff and pupils in English mainstream primary mathematics classrooms with VI pupils, first in an exploratory phase (Phase 1), and then in an intervention phase (Phase 2). By "discourses", we denote utterances—expressed through speech but also through gestures, facial expressions, and bodily expressions in general, which relate to inclusion and/or disability and which are expressed by the participants either during the lesson or outside the lesson. The discourses may signify the participants' attitudes towards—and/or experiences of—inclusion and disability [9].

In Phase 1, we investigated how class teachers, teaching assistants, and sighted pupils consider inclusion and disability in the context of the mathematics classroom, and with regard to VI pupils. We examined whether there are any variations amongst different participants in the same classroom in their consideration of inclusion and disability. We also identified how consistent the participants' discourses are with the discourses on inclusion and disability in the participating schools' policies; the SEND code of practice [27], which is the UK's educational code of practice for children and young people with Special Educational Needs and/or Disabilities; and international policies on inclusion and disability [1,2,22]. In Phase 1, we used classroom observations, focused group interviews, and individual interviews.

In Phase 2, we examined evidence from Phase 1 on inclusion and disability. With the aim of bringing the practice closer to endorsed principles in international legislation on inclusion and disability, we designed mathematics lessons with the participating teachers that the teachers then trialled in the classroom. These lessons aimed to be experienced as enabling and inclusive by the VI pupils and as beneficial to every pupil. The study explored, and aimed to provide specific evidence on, the social and educational benefits—which emanate from the implementation of inclusive education in the classroom—to all pupils. The lessons also serve as a platform for us to examine participants' potential discursive shifts regarding inclusion and disability. In Phase 2, we used written transcripts of the class teachers' contributions to the design of the three intervention lessons, classroom observations, focused group interviews, individual interviews, photographs of the pupils' work in the three intervention lessons, and pupils' evaluation forms of the intervention lesson in two classes.

Stylianidou's [12] study addressed the following research questions: How are inclusion and disability constructed in the discourses of teaching staff and pupils in the mathematics classroom? How do collaboratively designed mathematics lessons impact upon teaching staff and pupil discourses on inclusion and disability? The first research question was explored in both phases of the study while the second research question was explored in Phase 2.

For the purposes of this paper, we extracted data and analyses from [12] in order to answer the teacher preparation Research Questions formulated at the end of Section 2.

3.2. Context and Participants of the Study

Data collection was conducted in four primary mathematics classrooms (Y1, Y3 and two Y5 classes; pupils' ages varied from six to ten) in four mainstream schools in the county of Norfolk, UK. The VI pupils' presence and the willingness of teaching staff and pupils to participate in the study constituted the main criteria for the selection of participants. There is one VI pupil in three of the classes and two in the fourth. Most of the participating VI pupils had severe visual impairment and none of them was blind in both their eyes. Two pupils had congenital visual impairment while three had adventitious visual impairment ("Congenital" and "adventitious" have to do with the age of onset of visual impairment. Congenital VI are individuals who have been born with visual impairment while adventitious VI are the individuals whose visual impairment has appeared later in life). We collected data after securing ethical approval by the University of East Anglia's Research Ethics Committee and we ensured participants' consent as well as their anonymity, confidentiality and right to withdraw from the study.

Every class had at least one teaching assistant, but the teaching assistant's role differed from class to class. While two of the classes had a teaching assistant supporting the VI pupils almost exclusively; in the other two classes, the teaching assistants supported pupils who needed help in particular instances and their role did not focus on supporting the VI pupils specifically.

We coded the names of classrooms and of teaching staff and have used pseudonyms for the names of pupils.

3.3. Data Collection

We collected data through the observations of 29 mathematics lessons (33.5 h in total); individual interviews with five class teachers (six interviews, 2 h and 10 min in total); individual interviews with four teaching assistants (six interviews, 2 h and 15 min in total); focused group interviews with 35 pupils (16 interviews, 2 h in total); two ten-minute individual interviews with one pupil; written transcripts of the teaching staff's contributions towards the design of the three lessons that constituted the intervention phase of the study; photographs of the pupils' work in the three intervention lessons; and, pupils' evaluation forms of the intervention lesson in two classes. In one of the classes taught by two teachers—on different days—both teachers were interviewed. During the observations, written notes were kept for all lessons. Twenty-one lessons were audio-recorded, and 14 lessons were audio/video-recorded. All interviews were audio-recorded, except four, following interviewee requests. For these, written notes were kept instead.

3.4. Data Analysis

Our unit of analysis for the classroom observation data is the classroom episode. Our choice of episodes as analytical units resonates with the use of this method in [9,24] studies on the inclusion of VI pupils in the mathematics classroom. We define a classroom episode as a part of the mathematics lesson that has a starting and an ending point and thus can stand alone in the text with relative clarity, and that also has the capacity to convey a key point related to the focus of the study. Applying this definition to the classroom observation data, we broke each lesson down into episodes. In particular, in each lesson, we examined the classroom observation data, and we broke them into episodes.

The labels of the episodes illustrate the ways in which inclusion and/or enabling of VI pupils took place in the mathematics lesson, along with their impact on the VI pupils. The impact was elicited from the VI pupils' (re)actions during the mathematics lesson. We then collected all the labels, grouped similar labels together, and discerned the themes that the grouped labels fit to. Afterwards, within each theme and with the help of the labels, we identified the issues that concerned each theme.

In the data analysis sections of Phase 1, data from individual interviews and from focused group interviews were used to support, deepen, expand, or contradict issues that emerged from the analysis of classroom episodes. Data from the lesson design, classroom observations, individual interviews, focused group interviews, and evaluation forms informed the data analysis sections of Phase 2.

In what follows, we draw on the data and analyses in [12], first to identify inclusion issues on resource use in mathematics teacher education, and then to examine the circumstantial and—crucially for the MTE focus of this paper—systemic origins of these issues (Section 4.1). We then present evidence on how these issues fed into teacher–researcher collaborative design and implementation of inclusive classroom activities for the benefit of everyone in the class (Section 4.2).

4. Data Analysis and Findings

We first discuss the opportunities and challenges in using digital/physical resources in inclusive mathematics education, focusing on MTE issues (Section 4.1). We then present teacher–researcher collaborative design and implementation of inclusive mathematics lessons, offering a critical reflection (Section 4.2).

4.1. Opportunities and Challenges in Digital/Physical Resource Use for Inclusive Mathematics Education (and MTE Issues Thereof)

In Section 4.1, we summarise findings from the exploratory phase in [12] that provide evidence of inclusion issues on resource use in mathematics education. We use critical evidence from episodes that highlight where the effectiveness of teachers' practice can be further supported (in current practice as well as in MTE).

4.1.1. Teacher Positioning: When Teaching Becomes Inadvertently Inaccessible

While we have found that digital resources mediate VI pupils' visual access to the teacher's physical demonstration, we saw evidence of bodily discomfort in the VI pupil that was associated with the teacher's position in her physical demonstration. The teacher's position often appeared to impede the inclusion of the VI pupil (as evidenced by the Fred case in Figures 1–3). Her bodily position often resulted in aches in the VI pupil's back and arms as he held his iPad towards her. The bodily discomfort sometimes prompted the VI pupil to give the iPad up (see Figure 4). The teaching assistant often intervened by trying to include the VI pupil through the use of his iPad (see Figure 5).

The bodily position of the teacher constitutes a circumstantial obstacle. This obstacle is associated with Roos's finding regarding "the importance of the teacher when aiming for inclusion in inclusive mathematics classrooms" ([28] p. 240), especially, as Roos stresses, when inclusion is hindered because of reduced accessibility to the support offered by the teacher.

Figure 1. Fred sits up with his elbows in the air. He holds his iPad towards the teacher's physical demonstration.

Figure 2. Fred has his back stretched and is leaning towards the teaching assistant, with his right elbow on his table. He continues to follow the teacher's physical demonstration on his iPad.

Figure 3. Fred moves his body, as seen with his posture in Figure 1. He continues to hold his iPad towards the teacher's physical demonstration.

Figure 4. Before the teacher completes her question, Fred puts his iPad away and makes a facial expression of tiredness and disappointment.

Figure 5. The teaching assistant gives the iPad to Fred to follow the teacher's physical demonstration. Fred takes the iPad, making a facial expression of unhappiness.

4.1.2. A VI Pupil's Desire to Not Stand out and School Narratives about Disability as Deficit, Not Difference

Another issue that occurs in tandem with, and sometimes emanating from, the aforementioned issue of the teacher's positioning, is the VI pupil's preference for physical resources over digital ones for his inclusion in the teacher's physical demonstration. In our earlier example, despite the inclusive intentions of the teacher—she expects the VI pupil to use his iPad to follow her physical demonstration—and although these intentions are associated with the intertwinement of the VI pupil's digital resource and the teacher's physical resources, the iPad does not prove to be a satisfactory mediating tool for the VI pupil. When an opportunity to use the physical resources appears, the VI pupil grabs this opportunity (see Figure 6).

Inclusion, through the VI pupil's use of a digital resource, aims to be achieved also by the teaching assistant. The teaching assistant insists that the VI pupil should follow the teacher's demonstration from his iPad, despite seeing that the VI pupil is unwilling to use it and is interested in using physical resources. It is only when she sees the VI pupil continuously refuse to use his iPad (Figure 7), that she includes him through the use of physical tools.

Figure 6. Fred moves the iPad case to cover its screen when the teaching assistant opens the box with the physical blocks.

Figure 7. Fred works visually and tactilely with the physical blocks. The teaching assistant has given him 220 while the teacher has given 230 to the three sighted pupils—the teaching assistant missed the teacher's earlier giving of one block of Ten to the Tens pupil. Fred needs to lean that much to be able to see the blocks—otherwise he cannot see them.

While we found that digital resources mediate VI pupils' visual access to the teacher's hybrid physical–digital demonstration (see Figure 8), the teacher's emphasis on the VI pupil's use of digital resources is not as effective, due to the VI pupil's desire to not do something that makes him stand out amongst his sighted peers. Being the only pupil who is given a special mediating tool seems to upset the VI pupil. His looks towards the Interactive Whiteboard, from which he cannot access the teacher's hybrid physical–digital demonstration, seem to be a way to express his objection to being the only one who is asked to use a special tool for his inclusion. Unlike our previous examples, the iPad is not associated with any obvious, noticeable, external, physical (namely, bodily) discomfort for the VI pupil, it is associated with inner, emotional discomfort (namely, the feeling of being singled out from the rest of the class).

The VI pupil's reluctance to use his iPad constitutes a systemic obstacle because it is rooted in how the pupil sees his school's consideration of difference. The school may not always seem to cultivate positive connotations of disability as difference (not deficit) with regard to visual impairment and this narrative seems to be endorsed by the pupil who simply does not want to stand out in any way. Providing special digital resources to the VI pupils—iPad and computer—and being asked to use these in almost every part of the mathematics lesson is one way in which the VI pupil is made to feel different from the rest of the class (we acknowledge of course the well-intended underpinning of this provision, which is to help the VI pupil access what their sighted peers access). Another way in which the VI pupil is made to feel different from the rest of the class is the insistence on using resources that mainly try to mitigate limitations in sight. Again, the VI pupils' difference is not celebrated, as the VI pupils are asked to use their limited vision to construct mathematical meaning. They are rarely asked to use other sensory channels—such as touch, to which they have fuller access—in their mathematical learning.

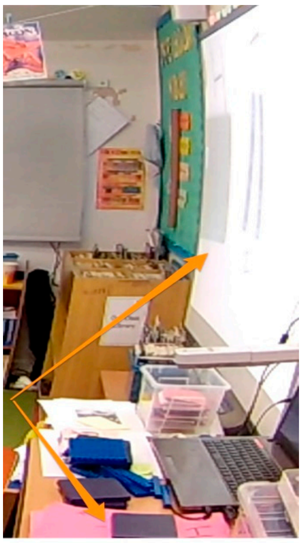

Figure 8. 127 demonstrated with physical blocks on the visualiser and projected on the IWB.

This systemic obstacle has repercussions on pupils' sense of belonging which, according to Rose and Shevlin [29], constitutes another key aspect of inclusion: the reluctance to use the iPad is an indication by the pupils that they do not belong to the classroom community, and their feeling of not belonging needs to also be considered when we aim towards a more inclusive mathematics teacher education [30]. This obstacle also resonates with Buhagiar and Tanti's point ([31] p. 72) that disabled pupils "were physically present in the class, but they did not seem to be part of it".

This systemic obstacle is also associated with Roos's [28] finding regarding the dislike of mathematics as a hindering issue for inclusion and how this dislike has sociopolitical underpinnings. As Roos [28] indicates, the label "special needs students" creates obstacles for inclusion, and the ideological way of using inclusion at school often generates exclusion. Implicit in Roos' statement is the problematic notion of the "normal" student. Schools cannot become inclusive when they are underpinned by the notion of the "normal" student: this notion legitimises exclusion, since it separates students who differ from the sociopolitical connotations of this kind of student as problematic and in need of remediation [10].

While we have found that hybrid physical–digital resources mediate VI pupils' visual and tactile access to physical resources, the teacher's limited awareness of the VI pupil's visual needs constitutes an inclusion issue on resource use in mathematics education. Despite the inclusive intentions of the teacher—she expects the VI pupil to use his visualiser to access the physical worksheet—and although these intentions are associated with intertwinement of the VI pupil's hybrid physical–digital resource and his physical resource, this intertwinement is sometimes not experienced by the VI pupil. Therefore, the inclusive intentions of the teacher become problematic for the VI pupil because he is invited to be included in a way that he is not comfortable with.

The appropriate adjustment of a physical resource to the needs of the VI pupil constitutes a systemic obstacle. This obstacle is systemic because it is rooted in the school's consideration of inclusion and, in particular, in the class teacher's role with respect to the inclusion of VI pupils. While pre-service and in-service training on the inclusion of VI pupils for class teachers is limited, training on the inclusion of VI pupils is provided to teaching assistants. These two facts indicate the systemic view that there should be a 'special' person—not the class teacher—responsible for the VI pupils. This may suggest an institutional narrative about inclusion as a transplantation of special education in mainstream settings [32]. Instead, as Noyes [33] and Ingram [34] also stress, knowing the pupils, and teaching in accordance with pupils' needs, constitute key factors of productive and sensitive inclusion.

While we have found that physical resources mediate VI pupils' visual and tactile access to the teacher's digital demonstration, the VI pupil's unfamiliarity with using physical resources constitutes an inclusion issue on resource use in mathematics education. This unfamiliarity stems from the teaching staff's emphasis on digital resources: the VI pupil is mostly asked to follow teacher demonstrations through a digital resource, and he is rarely asked to use physical resources to access these demonstrations. Even in the rare cases in which he uses physical resources to construct mathematical meaning, he is not encouraged to use touch as a sense to construct mathematical meaning: he instead employs his limited vision—and this is, again, related to tacit sociomathematical norms established in the classroom that pertain to the privileging of vision in mathematical learning. The VI pupil's reliance on his limited vision is often associated with a mistaken following of the teacher's digital demonstration (see Figure 9). We speculate that, had the VI pupil relied on touch, the mistakes could have been avoided.

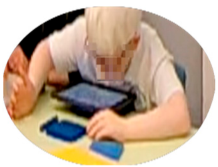

Figure 9. Fred pushes 4 blocks of Ones—instead of 3—with his right hand, without looking at his iPad.

4.1.3. Coordinating a Teacher's and a Teaching Assistant's Interventions in Assisting a VI Pupil

Despite the inclusive intentions of the teaching assistant—she assists the VI pupil in his mathematical work with physical resources (see Figure 10)—and while these intentions are associated with intertwinement of the teaching assistant's whiteboard and the teacher's digital demonstration (see Figure 11), the teacher shared with us after the lesson that the teaching assistant's intervention makes the VI pupil merely more dependent upon the teaching assistant's presence as a substitute for mere access to what he cannot see. Again, the support provided to the VI pupil neither enables nor celebrates his access to sensory channels other than sight (e.g., touch). Implicit narratives about the under-valued role of (e.g.,) touch in making mathematical meaning with VI pupils are examined in [24] who report that VI pupils are rarely provided with opportunities to use touch and in [6], from a student's point of view,

> *"The students had explained to us that it was rare for them to interact with representations of geometrical shapes, and an important aspect of designing the tasks was to produce tactile materials that would make this possible"* ([24] p. 134)

and from a teacher's point of view,

> *"According to the two teachers the lack of materials had a great impact on Nefeli's haptic apprehension and for this the researchers prepared and provided the teachers material following exactly the activities suggested in the school textbook".* ([6] p. 129)

The aforementioned obstacles indicate that "inclusion is a complex process of participation where both ideological and societal issues, as well as individual and subject-specific issues, must be considered in the educational endeavour" ([28] p. 244). To optimise the intertwinement of physical and digital resources, we need to overcome these, and other, circumstantial and systemic obstacles. We note that both—particularly the latter—are harder to overcome, as they are located in deeply rooted institutional narratives about what constitutes a legitimate mode of mathematical learning. In Phase 2, we and the class teachers attempted to overcome these two groups of obstacles. We report on our collaboration in what follows.

Figure 10. Fred follows the teacher's working out of the calculation from the teaching assistant and her whiteboard. The teaching assistant looks at the teacher's demonstration on the IWB.

Figure 11. The teaching assistant writes the column addition on her whiteboard while the teacher is writing it on the IWB. Fred continues to rub his eyes.

4.2. Teacher–Researcher Collaborative Design and Implementation of Inclusive Mathematics Lessons (and Critical Reflection Thereof)

Here, we discuss how the class teachers and we (primarily the first author and doctoral researcher) tried to tackle the obstacles—that were identified in the exploratory phase—in our collaborative design of the intervention lessons. We present our collaborative efforts with the teacher and reflect critically on these efforts. We do so to propose that, beyond pre-service teacher education, ongoing collaboration/professional development is a necessary and potentially productive way forward for the sustainable efforts needed to create inclusive mathematics classrooms. We summarise findings on resource use that arose after the implementation of the intervention lessons: we focus on the 'what' and 'how' of the design with the teachers as well as on the implementation of the design (with a particular focus on resources used towards the support of VI pupils' mathematical learning).

4.2.1. Overview of Design Priorities and Issues

In the design of the intervention lessons, the class teachers and the first author decided not to involve the teaching assistants in the inclusion and enabling of the VI pupils. Instead, we decided to design the lessons in such a way that the class teachers were primarily responsible for the inclusion and enabling of these pupils. Cases where the class teachers are responsible for the inclusion and enabling of VI pupils are also seen in the literature (e.g., [7,35,36]). For example, Sticken and Kapperman [36] report on the complexities emerging out of limited coordination when inclusion is implemented by the class teacher and the support teacher.

The obstacles that arose in the exploratory phase with regard to the inclusion of VI pupils through digital resources prompted the class teachers and the first author to shift towards exploring alternative ways to include these pupils. These involved the design of tactile and auditory resources that do not require vision to be accessed, but that invite the use of other sensory modalities by the class. Our design of tactile and auditory resources for VI pupils was also informed by the literature (e.g., [6,37,38]).

The obstacles that arose in the exploratory phase with regard to the VI pupils having mistakenly followed the teachers' digital demonstrations with their physical resources prompted the class teachers and the first author to shift towards designing mathematical tasks that are experienced through touch—and not just by the VI pupils [39]. We aimed to increase the familiarity of the whole class with touch and to show the significance of touch in mathematical learning. In this respect, our focus on tactile mathematical tasks addressed to every pupil differed from that in the literature (e.g., [6,37,38]). The literature focuses on addressing these tasks only to the VI pupils, with the sighted pupils working on visually based tasks. In other words, the literature focuses on 'translating' sighted pupils' tasks to the needs of the VI pupils under the principles of adaptation/differentiation/accommodation. However, we focussed on designing tasks that address every pupil's needs under the principle of universal design for learning [1].

Our collaborative design of the intervention lessons was on the mathematical topics and learning objectives that the class teachers had planned to be working on the day of the lesson implementation. In addition, the lessons were co-designed in a way that teachers felt comfortable with. As the lessons were implemented by the teachers, and as they aimed to trigger long-lasting changes in the classroom, they needed to be substantiated with the teachers' contributions and agreed upon with the teachers.

In what follows, we present two auditory and two tactile mathematical tasks (and mention a third one briefly) that the class teachers implemented in the Phase 2 lessons. We first present two auditory tasks, both of which are based on number sequences: the first task was co-designed by a teacher at School 3 and the first author; and, the second task was co-designed by a teacher at School 4 and the first author (and was based on preliminary findings from the implementation of the first auditory task). We then present two tactile tasks. The first task is based on number sequences and was co-designed by the teacher at School 3 and the first author. The second task is based on shapes and was co-designed by the teacher at School 2 and the first author (and was based on preliminary findings from the implementation of the first tactile task).

4.2.2. First Auditory Task on Number Sequences

In the Y1 class at School 3, the teacher plays a single, low sound on a xylophone and tells the class that, when they hear this sound, it is a Ten. She then takes another xylophone, plays a single, high sound, and tells the class that, when they hear this sound, it is a Unit. Afterwards, she plays various sounds, sometimes by using one xylophone and sometimes by using both xylophones. Each time, she asks the class what number she plays. She then plays number sequences with a pause in between two successive numbers and asks pupils to move towards her and play the next numbers. Afterwards, she asks the class if the sequences are increasing or decreasing and by how much.

In this task, the teacher expected the class to discern number sequences through the use of hearing—by listening to number sequences represented via musical instruments. She expected to hear mathematical contributions commensurable with Y1 curricular requirements [40]:

- discern numbers;
- discern number sequences;
- say what the next number is in the sequences;
- explore place value;
- say if the sequence increases or decreases—and by how much.

The primary aims of this task were: to invite the class to experience number sequences through the sense of hearing—by the teacher incorporating music into Mathematics and to investigate the mathematics elicited through the auditory experience.

The use of the auditory construction of mathematical meaning contributed to the teacher's realisation that she should distinguish between focussing on mathematics and looking at the teacher/board. Before this task, this teacher—as well as other teachers—confused these two situations. More specifically, they posited that, if the VI pupil does not look at them or the board, he is not focussed. In this task, she realised that the fact that the VI pupil (Ned) does not look at her does not necessarily make him lose focus: this is because, in this task, mathematical learning is constructed in the auditory—not visual—modality. The teacher particularly reported:

> *"I did think music still allowed him to access that, so often Ned is not focussed—I mean he is not looking at the board, so he is missing key learning—but, because he wasn't looking necessarily up, I think maybe he can still listen to what was going on, so he could still kind of grasp what was going on."*

The active involvement—and the use of musical instruments—in the representation of number sequences by the teacher, as well as the invitation to the class to play the next number on the musical instruments, were particularly beneficial for both the sighted and the VI pupils.

Both mathematical and social benefits arose. With regard to mathematical benefits, we indicatively report the following: ease in discerning between Tens and Ones through music; translation of each sound into its place value representation; clarity of the patterns in number sequences via music. With regard to social benefits, we indicatively report the following: pupils realised that music and Mathematics are not necessarily disconnected from each other, but rather that music can be productively used in Mathematics; the auditory task made pupils relax—they associated music with Mathematics and considered relaxation as the effect of music upon them.

4.2.3. Second Auditory Task on Number Sequences

In the Y5 class at School 4, the teacher asks the class to work in pairs. Each pair needs to create a number sequence of five numbers, with the first number having two digits. The teacher tells the class that they will need two sounds for each number: one sound to represent a Ten; and, one sound to represent a Unit. Each sound will need to come from a different musical instrument. One pupil in each pair will represent the Tens and the other pupil will represent the Units. The teacher then asks the class to take musical instruments and to start creating, and then practising, their number sequences in their pairs.

Afterwards, each pair plays their number sequence to the rest of the class and the rest of the class tries to work out what the numbers are—and what the rule is—in that sequence. The teacher tells the class that it is up to them how they record the number sequences.

In this task, the teacher expected to hear mathematical contributions commensurable with Y5 curricular requirements [40]:

- discern number sequences
- express the rule in the sequences
- create number sequences

The primary aims of this task were to invite the class to experience number sequences through their sense of hearing—by the teacher incorporating music into Mathematics, to investigate the mathematics elicited through the auditory experience, and to invite the class to construct number sequences in pairs and then represent these sequences through musical instruments.

In this task, the teacher suggested asking pairs of pupils to construct, and then play, a number sequence using musical instruments. We now explain why these were good suggestions.

Her invitation towards pupils to work together reinforced pair work, which was missing from that class in Phase 1. We indicatively report the following benefits from pair work for VI and sighted pupils:

- The VI pupil (Ivor) was better included in the class, he was no longer a separate member from the sighted community of learners. Ivor particularly acknowledged that today's mathematics lesson was "[t]otally different" to the one he normally has. One of the differences that he pointed to was that "we were put in partners today". He pinpointed that he likes working with a peer because "[t]hey can help one another". He found it "[k]ind of easy and odd" that he did not work with the teaching assistant tin the lesson: "Easy because it was just like stuff and sequences, and I just knew what sequences were";
- There was mutual appreciation between the VI pupil and his sighted peer (Frank), both mathematically and socially. For example, Ivor helped Frank with the last number in their sequence: While Ivor correctly did not play any Tens for "6", Frank did not play any Ones—he possibly thought that it was Ivor's turn and he did not look at the number. Ivor made a facial expression to Frank showing that it was Frank who had to play that number. Frank played it. Therefore, while in Phase 1 Ivor was helped by others and appeared to be weak and distracted in Mathematics, in Phase 2 Ivor helped his sighted peer. This finding from Phase 2 illustrates Ivor's very good understanding of place value and also the very good collaborative skills between Ivor and his partner;
- Pupils liked the collaborative production of mathematical ideas.

We now present benefits from pair work as reported by the teacher:

- All children participated in and were actively engaged in the lesson;
- There seemed to be no pattern in the work of High Achieving Pupils (HAPs), Middle Achieving Pupils (MAPs) and Low Achieving Pupils (LAPs) in the auditory task. This task helped blur the boundaries across ability groups (and cast some doubt on the utility and purpose of such groupings). Specifically, some LAPs found it easy and some HAPs found it hard. This finding raises the need to discuss on which terms "ability groups" are decided and how accurate these decisions are.

Benefits from pair work were also reported by the teaching assistant: real engagement and excitement of the children, albeit somewhat noisy; good work in pairs; appreciation of our principle with mixed-ability pairs and our choice of pairs; the VI pupil was very much included and concentrated.

The teacher's invitation of pairs of pupils to play a number sequence using musical instruments reinforced:

- the pupils' active involvement in the construction of mathematics through music;

- the rest of the class's development of the auditory modality in the construction of mathematical meaning. For example, Ivor told the first author that "listening to the bits of music" and "listen[ing] [. . .] about the sequences" were what made him concentrate. In Phase 1, Ivor told her that he felt distracted and did not concentrate much in the lesson when he did not work with the teaching assistant. In the Phase 2 lesson, he told her that he concentrated even though he did not work with the teaching assistant. He also told her that, in the Phase 2 lesson, he did not find it hard to follow the lesson from the class teacher. In Phase 1, he told her that he found it hard to follow the maths lesson from his class teacher and that he instead found it helpful to work with the teaching assistant in mathematics. He specifically said: "I couldn't keep up with the teacher but now I can".

The mathematical and social benefits that arose in this second auditory task are similar to the ones reported in the first task.

4.2.4. First Tactile Task, Number Sequences

In the Y1 class of School 3, the teacher introduces to the class an A3 worksheet which includes four number sequences in a landscape format. Above the printed numbers, Wikki Stix is stuck so that the number sequences can be felt. The teacher moves around the classroom and invites pupils to close their eyes, feel numbers on the worksheet and tell her what the numbers are. She then asks some pupils how many Tens and how many Ones they need for the numbers that they have felt.

In this task, the teacher expected to hear mathematical contributions commensurable with Y1 curricular requirements [40]:

- 'read' numbers. We enclose "read" in quotation marks because this term is contextualised in this task differently—not through the visual sense. More specifically, "read" is contextualised as discerning numbers through the tactile sense;
- discern number sequences;
- explore place value.

The primary aims of this task were to invite the class to experience number sequences through their sense of touch by becoming familiar with Wikki Stix, which is often used by VI pupils, and to investigate the mathematics elicited through the tactile experience.

4.2.5. Second Tactile Task, Shapes

In the Y5 class of School 2, the teacher holds a bag with a range of 2D plastic shapes. He moves around the classroom and invites pupils to put their hands in the bag, pick one shape without taking it out of the bag and without looking at it, feel it and then describe it to the rest of the class. The teacher is the only one who has visual access to that shape, which remains in the bag.

In this task, the teacher expected the class to describe the given shapes through touch. He expected to hear descriptions of shapes commensurable with Y5 curricular requirements:

- name particular shapes (e.g., "rectangle", "hexagon");
- discern whether these particular shapes are 2D or 3D;
- name the properties of these particular shapes with regard to
    - sides: number of sides, if any sides are equal to each other, if any sides are parallel to each other, if there are straight and/or curved sides
    - vertices: number of vertices
    - angles: number of angles, types of angles.

The primary aims of this task were to invite the class to experience shapes through their sense of touch and to investigate the mathematics elicited through tactile experience. For these two reasons/aims, the teacher was open to the mathematical contributions of the class that stemmed from their tactile experiences, and he did not strictly request the class to respond with regard to all the mathematical properties listed above.

This task was suggested by the teacher, in resonance with our design principle asking the entire class to explore mathematics through touch. It complements the task we present in [39] where Wikki Stix is used to make and describe shapes.

The mathematical benefits that arose from this task reinforced the mathematical benefits of the tactile task that the first author had suggested. More specifically, pupils reported mathematical benefits pertinent to touch and to its characteristics. For example:

- Touch allowed pupils to "count the edges, sides, corners and vertices";
- Touch allowed pupils to realise "the hidden facts on the shapes";
- Touch allowed pupils to "have to feel around to get it";
- Touch allowed pupils to "realis[e] [. . .] the differences";
- Touch allowed pupils to "move the shapes".

The pupils reported they "liked" the following in their engagement with this task:

- "touching the shapes and describing them";
- "closing my eyes and feeling the shapes, trying to figure out what they were";
- "picking into the bag and describing it";
- "the different way to learn about shapes";
- "feeling the shape and getting it correct";
- "feeling" the shapes/the "feel" of the shapes;
- the "weird" feeling that touch generated for them.

This task also reinforced:

- gestures as a tool for construction—and expression—of mathematical meaning. Gestures were particularly used by sighted pupils, the VI pupil, and the teacher in the construction and expression of mathematical meaning;
- the verbal mathematical language that is elicited through tactile experiences (e.g., "it feels").

As a result, the class and the teacher appreciated the opportunity to use touch in mathematical learning and experience, first-hand, the mathematics that touch can help to create.

To sum up, a range of findings arose during the implementation of these tasks. First, the tasks were experienced by both VI and sighted pupils with palpable excitement. No special resources were needed for the VI pupils, and everybody accessed the tasks using a sense to which they have full access. Compelling mathematical contributions by both VI and sighted pupils also arose from the use of these types of resources.

Apart from benefits to the pupils, the tactile and the auditory tasks were also of benefit to the teaching staff. The teaching staff also experienced visible excitement with the use of these resources. They acknowledged the mathematical and social benefits of these tasks, and evaluated touch and hearing as senses that have relevance and potency in mathematical learning.

In Phase 1, the teachers considered vision as the prevalent sense in mathematics, with rare use of touch and hearing implying that they are seen as being of secondary importance. In Phase 2, they were more open to, and appreciated, touch and hearing as valued sensory channels for mathematical learning. This openness made them diverge from the institutional norms that emphasise vision as a dominantly relevant sense in mathematical learning. They considered other senses as intellectually valid, and therefore moved away from considering certain senses as more intellectually valid than others. This openness may enable the design of more tactile and auditory tasks in the mathematics classroom, for the benefit of everybody.

5. Towards Inclusive Mathematics Classrooms: Implications for Teacher Education

Our co-designed intervention lessons with the teachers suggest that ongoing collaboration and professional development constitute necessary and potentially productive ways forward for the sustainable efforts needed to create inclusive mathematics classrooms. However, we argue that well-meaning individual teacher–researcher collaboration is not a sufficient condition for such interventions to scale up. It is necessary that inclusion issues should be addressed in teacher education (pre-service and in-service) so that the changes towards a more inclusive mathematics education are communicated to all pre-service and in-service teachers rather than at a small scale (a researcher and a few teachers, doing a bit of work together). We conclude by discussing implications for teacher education towards inclusive mathematics classrooms.

In this paper, we aimed to answer Research Question 1 (teacher preparation needs with a particular focus on the use of resources for inclusion in mathematics lessons) and Research Question 2 (the pedagogical potentialities of teacher–researcher collaborative design and implementation of inclusive classroom activities that benefit VI and sighted learners). We identified specific and particular limitations in the preparation of teachers reported more broadly in the literature (e.g., [24]) that are associated with inclusion issues on resource use under the following themes: teacher positioning; VI pupils' desire to not stand out versus school narratives about disability as deficit, not difference; and coordinating teachers' and teaching assistants' interventions in assisting VI pupils. We identified circumstantial, but mostly systemic, obstacles associated with institutional narratives about inclusion, disability, and mathematical learning. Teacher–researcher collaborative design and implementation of inclusive classroom activities [26] was found to be a successful way to address those issues and, ultimately, create inclusive mathematics lessons. Within this teacher–researcher collaborative paradigm, we substantiated the mathematical and social benefits to all learners that are aspired to in international legislation (e.g., [2]) as outcomes from the implementation of inclusive education. Amongst the benefits, we found clarifications of, and confidence in, mathematical topics, teamwork, and the active involvement of all pupils. While the scale of our efforts is modest, our findings nonetheless highlight potential ways forward as to how MTE programmes may better prepare teachers—and how they can do so at a larger and more substantial scale.

We envisage that the following implications will contribute towards MTE that pays more—as well as more specific and better tailored—attention to inclusion in mathematics lessons. The teachers' and the teaching assistants' support for VI pupils needs to be better aligned and orchestrated towards a common goal. Teacher training should facilitate teacher awareness of the VI pupils' perceptual needs and capabilities. It should also cultivate positive connotations of difference (e.g., with regard to visual impairment, with regard to pupils' mathematical contributions that differ from those seen as standard). Last but not least, teacher training should encourage the design and deployment of classroom resources in a way that VI pupils, and the rest of the class, can use a multiplicity of sensory channels, such as touch and hearing, for mathematical meaning making and communication. Further research needs to focus on continued collaborative work with teachers towards the design of more multimodal mathematical tasks for the benefit of everybody in class, disabled and able-bodied learners alike.

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References

1. United Nations. *United Nations Convention on the Rights of Persons with Disabilities*; 2006. Available online: http://www.un.org/disabilities/documents/convention/convoptprot-e.pdf (accessed on 13 September 2023).
2. UNICEF. *The Right of Children with Disabilities to Education: A Rights-Based Approach to Inclusive Education*; 2011; Available online: https://www.academia.edu/34873139/The_Right_of_Children_with_Disabilities_to_Education_A_Rights-Based_Approach_to_Inclusive_Education_in_the_CEECIS_Region (accessed on 13 September 2023).
3. Office for Disability Issues. *UN Convention on the Rights of Persons with Disabilities: Initial Report on How the UK is Implementing It*; 2011. Available online: https://www.gov.uk/government/publications/un-convention-on-the-rights-of-persons-with-disabilities-initial-report-on-how-the-uk-is-implementing-it (accessed on 13 September 2023).
4. Department for Work & Pensions and Office for Disability Issues. 2019 Progress Report on the UK's Vision to Build a Society Which Is Fully Inclusive of Disabled People. 2018. Available online: https://www.gov.uk/government/publications/disabled-peoples-rights-the-uks-2019-report-on-select-recommendations-of-the-un-periodic-review/2019-progress-report-on-the-uks-vision-to-build-a-society-which-is-fully-inclusive-of-disabled-people (accessed on 13 September 2023).
5. Department for Education. Initial Teacher Training (ITT) Market Review Report. 2021. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/999621/ITT_market_review_report.pdf (accessed on 13 September 2023).
6. Argyropoulos, V.; Stamouli, M. A collaborative action research project in an inclusive setting: Assisting a blind student. *Br. J. Vis. Impair.* **2006**, *24*, 128–134. [CrossRef]
7. Bayram, G.İ.; Corlu, M.S.; Aydın, E.; Ortaçtepe, D.; Alapala, B. An exploratory study of visually impaired students' perceptions of inclusive mathematics education. *Br. J. Vis. Impair.* **2015**, *33*, 212–219. [CrossRef]
8. Healy, L.; Ferreira, H. Changing perspectives on inclusive mathematics education: Relationships between research and teacher education. *Educ. Chang.* **2014**, *18*, 121–136. [CrossRef]
9. Nardi, E.; Healy, L.; Biza, I.; Fernandes, S.H.A.A. 'Feeling' the mathematics of disabled learners: Supporting teachers towards attuning and resignifying in inclusive mathematics classrooms. In *Mathematical Discourse That Breaks Barriers and Creates Space for Marginalized Learners*; Hunter, R., Civil, M., Herbel-Eisenmann, B., Planas, N., Wagner, D., Eds.; SENSE Publishers: Rotterdam, The Netherlands, 2018; pp. 147–170.
10. Healy, L.; Powell, A.B. Understanding and overcoming "disadvantage" in learning mathematics. In *Third International Handbook of Mathematics Education*; Clements, M.A., Bishop, A., Keitel, C., Kilpatrick, J., Leung, F., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 69–100.
11. Campbell, F. Inciting legal fictions: 'Disability's' date with ontology and the ableist body of the law. *Griffith Law Rev.* **2001**, *10*, 42–62.
12. Stylianidou, A. Investigating Inclusion and Disability in Teaching Staff and Pupil Discourses in Mainstream Primary Mathematics Classrooms in the UK: The Case of Visual Impairment. Ph.D. Thesis, University of East Anglia, Norwich, UK, 2021. Available online: https://ueaeprints.uea.ac.uk/id/eprint/85246/ (accessed on 13 September 2023).
13. Oliver, M. *Understanding Disability: From Theory to Practice*, 2nd ed.; Palgrave Macmillan: Basingstoke, UK, 2009.
14. Vygotsky, L.S. *Mind in Society: The Development of Higher Psychological Processes*; Harvard University Press: Cambridge, MA, USA; London, UK, 1978.
15. Vygotsky, L.S. *The Collected Works of L.S. Vygotsky: The Fundamentals of Defectology*; Rieber, R.W., Carton, A.S., Eds.; Springer: Dordrecht, The Netherlands, 1993.
16. Gallese, V.; Lakoff, G. The brain's concepts: The role of the sensory-motor system in conceptual knowledge. *Cogn. Neuropsychol.* **2005**, *22*, 455–479. [CrossRef] [PubMed]
17. Bingham, C.; Clarke, L.; Michielsens, E.; Meer, M.V.d. Towards a social model approach?: British and Dutch disability policies in the health sector compared. *Pers. Rev.* **2013**, *42*, 613–637. [CrossRef]
18. Mitra, S. The capability approach and disability. *J. Disabil. Policy Stud.* **2006**, *16*, 236–247. [CrossRef]
19. Palmer, M.; Harley, D. Models and measurement in disability: An international review. *Health Policy Plan.* **2012**, *27*, 357–364. [CrossRef] [PubMed]
20. LoBianco, A.F.; Sheppard-Jones, K. Perceptions of disability as related to medical and social factors. *J. Appl. Soc. Psychol.* **2007**, *37*, 1–13. [CrossRef]

21. Vygotsky, L.S. *Obras Escogidas V—Fundamentos da Defectología*; [The Fundamentals of Defectology]; Blank, J.G., Translator; Visor: Madrid, Spain, 1997.
22. UNESCO. *Conclusions and Recommendations of the 48th Session of the International Conference on Education (ICE)*; 2008; Available online: http://www.ibe.unesco.org/fileadmin/user_upload/Policy_Dialogue/48th_ICE/CONFINTED_48-5_Conclusions_english.pdf (accessed on 13 September 2023).
23. Healy, L.; Fernandes, S.H.A.A. The role of gestures in the mathematical practices of those who do not see with their eyes. *Educ. Stud. Math.* **2011**, *77*, 157–174. [CrossRef]
24. Healy, L.; Fernandes, S.H.A.A. The gestures of blind mathematics learners. In *Emerging Perspectives on Gesture and Embodiment in Mathematics*; Edwards, L.D., Ferrara, F., Moore-Russo, D., Eds.; Information Age Publishing: Charlotte, NC, USA, 2014; pp. 125–150.
25. Gallese, V. Embodied Simulation and its Role in Intersubjectivity. In *The Embodied Self. Dimensions, Coherence and Disorders*; Fuchs, T., Sattel, H.C., Henningsen, P., Eds.; Schattauer: Stuttgart, Germany, 2010; pp. 78–92.
26. Elliott, J. *Action Research for Educational Change*; Open University Press: Bristol, PA, USA, 1991.
27. Department for Education; Department of Health. *Special Educational Needs and Disability Code of Practice: 0 to 25 Years*; 2015. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/398815/SEND_Code_of_Practice_January_2015.pdf (accessed on 13 September 2023).
28. Roos, H. Students' voices of inclusion in mathematics education. *Educ. Stud. Math.* **2023**, *113*, 229–249. [CrossRef]
29. Rose, R.; Shevlin, M. A sense of belonging: Childrens' views of acceptance in "inclusive" mainstream schools. *Int. J. Whole Sch.* **2017**, *13*, 65–80.
30. Civil, M.; Planas, N. Participation in the mathematics classroom: Does every student have a voice? *Learn. Math.* **2004**, *24*, 7–12.
31. Buhagiar, M.A.; Tanti, M.B. Working toward the inclusion of blind students in Malta: The case of mathematics classrooms. *J. Theory Pract. Educ.* **2011**, *7*, 59–78.
32. Miles, S.; Ainscow, M. *Responding to Diversity in Schools: An Inquiry Based Approach*; Routledge: Abingdon, UK; New York, NY, USA, 2011.
33. Noyes, A. It matters which class you are in: Student centred teaching and the enjoyment of learning mathematics. *Res. Math. Educ.* **2012**, *14*, 273–290. [CrossRef]
34. Ingram, N. Engagement in the mathematics classroom. In *In Search of Theories in Mathematics Education: Proceedings of the 33rd Conference of the International Group for the Psychology of Mathematics Education*; Tzekaki, M., Kaldrimidou, M., Sakonidis, H., Eds.; PME: Thessaloniki, Greece, 2009; Volume 2, pp. 233–240.
35. Pinho, T.M.M.; Castro, H.C.; Alves, L.; Lima, N.R.W. Mathematics and blindness: Let's try to solve this problem? *Sch. Int. J. Multidiscip. Allied Stud.* **2016**, *3*, 215–225.
36. Sticken, J.; Kapperman, G. *Collaborative and Inclusive Strategies for Teaching Mathematics to Blind Children*. Available online: https://files.eric.ed.gov/fulltext/ED421821.pdf (accessed on 13 September 2023).
37. Healy, L.; Fernandes, S.H.A.A.; Frant, J.B. Designing tasks for a more inclusive school mathematics. In *Task Design in Mathematics Education: Proceedings of the 22nd International Commission on Mathematical Instruction Study*; Margolinas, C., Ed.; ICMI: Oxford, UK, 2013; pp. 61–68.
38. Leuders, J. Tactile and acoustic teaching material in inclusive mathematics classrooms. *Br. J. Vis. Impair.* **2016**, *34*, 42–53. [CrossRef]
39. Stylianidou, A.; Nardi, E. Tactile construction of mathematical meaning: Benefits for visually impaired and sighted pupils. In Proceedings of the 43rd Annual Meeting of the International Group for the Psychology of Mathematics Education, Pretoria, South Africa, 7–12 July 2019; Graven, M., Venkat, H., Essien, A.A., Vale, P., Eds.; University of Pretoria: Pretoria, South Africa, 2019; Volume 3, pp. 343–350.
40. Department for Education. (2013/2021). *National Curriculum in England: Mathematics Programmes of Study*. Available online: https://www.gov.uk/government/publications/national-curriculum-in-england-mathematics-programmes-of-study/national-curriculum-in-england-mathematics-programmes-of-study (accessed on 18 September 2023).