Research Design in Inclusive Learning Environments *For* and *With* Children on the Autism Spectrum – Towards Multimodal Data Collection

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ABSTRACT
Inclusive learning environments, in which children on the autism spectrum (AS) are educated alongside with neurotypical children, are being implemented by governments across Europe and world-wide. The rapid change towards implementing inclusive learning environments has resulted, however, in scarce research reports using multimodal data collected on social interactions in such environments. To this, our study presents a novel experimental multi-method research design to holistically capture natural interactions between children on the AS and neurotypical children in inclusive learning settings through multimodal data collection tools involving well-established as well as emerging educational technologies and methods: mobile eye tracking, wide-angle video cameras and video stimulated accounts (VSA). The children's perspectives regarding the practical research design implementation, as reflected in feedback forms collected, indicate that a relatively unobtrusive and non-distracting collection of multimodal data is achievable through sufficient planning and participatory strategies. This work contributes with a new multi-method research design to gather multimodal data in inclusive learning environments, looking at better understanding and strengthening children's social interactions. The multi-method research design described here can also be applied to other contexts, such as after-school activities or group therapy sessions.
Keywords: Autism; Multimodal data; Multi-method research design; Mobile eye tracking; Inclusive classrooms

INTRODUCTION
Autism is considered as a neurodevelopmental disorder characterised by disabilities in social interaction and communication (APA, 2013). In our work we use the terminology 'children on the autism spectrum (AS)' following the most recent preferred conceptual use of the term in the field of autism research (see for instance Bottema-Beutel et al., 2021). Over the past decade a rising paradigm in education has fostered an increase in the number of children on the AS in inclusive classrooms, promoting the education of all children side by side (e.g., Gledhill & Currie, 2020; Hodges et al., 2020; Lobo, 2020). Previous research on AS in educational contexts has commonly focused on individuals' interactional challenges and has been criticised for failing to consider how social interactions are *built in interaction with others* (e.g., Dindar, Lindblom & Kärnä, 2017; Lester, 2015). Furthermore, we can say that one important aspect in understanding social interactions is the natural context where those interactions are carried out (see for instance Lüddeckens' (2021) review of the literature on the social participation of adolescences on the AS). We, hence, perceive a gap on research designs to capture social interactions between children on the AS and neurotypical children, and how these interactions unfold in natural contexts, while children carry out a collaborative school task.

Nevertheless, we find studies reporting research designs in natural contexts but focusing on implementing peer-mediated interventions (PMI) to support the communication skills of children on the AS. Rodríguez-Medina et al. (2016), for instance, report a single-subject research design for a peer-mediated intervention (PMI) in school context, deployed during recess time to support the social interaction skills of a student on the AS (8-year-old). Their methodology included data collection methods based on systematic multiple-source observations from two researchers as well as participatory observations from teachers and peer students, which maximised the validity of the results as a study carried out in a natural context. Bambara et al. (2018) also report a PMI designed to support the conversational skills of high school students (four 14–20-year-olds) on the AS during lunch at school. Their non-concurrent multiple baseline design methodology included data collection through video and audio recordings, though a concern aroused regarding the feasibility of the intervention's practical implementation, which included training peer students as well as the students on the AS outside the natural intervention setting.

Since PMI emphasise the training of neurotypical children to interact with children on the AS, several studies reporting such interventions' implementation have also being carried out to support children on the AS' social skills during classroom activities. For instance, Jung et al. (2008) report the positive effect of a high-probability request sequence with an embedded peer modelling strategy intervention for increasing the compliant responses to social requests of three kindergarten children on the AS (5-6 year-olds). A high-probability request sequence refers to a number of requests that a child is more likely to execute when asked. The idea of the reported intervention was to facilitate the social interactions of children on the AS by increasing their responses to social requests. The study data was collected via videotape. Similarly, studies emphasising intervention models that incorporate children (9-11 year-olds) and adolescents (11-16 year-olds) on the AS' interests into activities with neurotypical peers, for instance establishing a lunch club group, have reported positive results related to improving the social skills of the participants beyond the intervention (Koegel, Fredeen et al., 2012; Koegel, Kim et al., 2013). These studies used videotapes, checklists, in vivo observations and questionnaires for data collection. (For a systematic review of the literature on peer-mediated intervention and other intervention models to support the social skills of children on the AS see for example Watkins et al., 2015).

These reported works have deployed research methodologies for interventions in natural settings, focusing on the collection of mono-type data, either in the form of systematic observations or video/audio recordings. Such research is often centred on evaluating interventions, to support social skills, that have been predominantly designed by researchers and professionals (e.g., Camargo et al., 2014; Ozdemir, 2008), or on observations on the social interaction skills between children on the AS and neurotypical children during school's recess (e.g., Dean, Harwood & Kasari, 2017; Locke et al., 2016). Only a few studies have embedded social interventions into curriculum or classroom-based activities, but they focused mainly on interaction during recess or lunch time (Sutton, Webster & Westerveld, 2019). Although recess times may seem ideal for social interaction with peers, many children on the AS may find them a welcomed break from socialising and prefer to play alone or simply observe the play of others (Calder, Hill, & Pellicano, 2013; Lang et al., 2011). The gap that exists, then, is in the reporting of the successful deployment of multi-method research design in an inclusive school environment towards a more comprehensive understanding of the interactions between children on the AS and children without a diagnosis.

Addressing this gap, this paper presents a multi-method research design for the acquisition of data in inclusive educational settings. The work presented in this paper is part of a larger research endeavour that focuses on investigating the strengths and challenges associated with the social participation of children in inclusive classrooms. Although research in this area exists, the studies have been limited in considering a) when and how children on the AS succeed in peer interactions, b) in studying children during their daily curriculum-based activities in natural school environments, and c) in increasing their participation in the research. The goal of our work is, therefore, to further research on these three aspects and to develop understanding and strategies to support the social participation of children on the AS. To this end, this manuscript introduces the multi-method research design that our work takes in order to collect various types of data in naturalistic inclusive education environments. This research design is novel in the combination of three different methods of data collection: *mobile eye trackers*, *video cameras* (representing emergent and well-established educational technologies, respectively (Arslan et al., 2022)) alongside *video stimulated accounts* (VSA) (Theobald, 2017). This interdisciplinary methodology also highlights the power in the combination of data analysis methods, appropriate to each data type collected, including gaze analysis for mobile eye tracker data, conversation analysis for video camera data and content analysis for exploring students' opinions and views of their own behaviours when they observe their recorded group work (VSA data). Here we also present the empirical evaluation data from the reported feedback that the students provided regarding the naturalness of the research environment design in their school.

RELATED WORK

Children on the AS are often at the periphery of the social networks in their inclusive classrooms and excluded from social participation (Kasari et al. 2011). Research has commonly focused on issues of social interaction and challenges of exclusion. Here we present a summary of related research in the areas of children on the AS' peer interactions, research carried out in natural environment with them, and these children's participation in research.

Children on the AS and peer interactions

Social participation in social interactions in general, and interaction with neurotypical peers in particular, have been found to be challenging for children on the AS. Individuals on the AS, through their childhood to adulthood, have been found to experience social exhaustion and poorer reported friendship quality (Crompton, Hallett et al., 2020; Kasari et al., 2011). In the school context specifically, exclusion from social networks, loneliness, and fewer reciprocal friendships have been reported (Kasari et al., 2011). Further, studies have shown that children on the AS spend more time engaged in solitary behaviour, less time engaged in cooperative interaction, and more time engaging in reactive aggression towards peers than their classmates who are not on the AS (Humphrey & Symes, 2011). Struggles with cooperation, assertion, self-control, hyperactivity and/or internalising behaviours have also been reported (Macintosh & Dissanayake, 2006; Graham, 2021). On the other hand, adolescents on the AS reportedly experience more instrumental verbal aggression from peers than other students (Humphrey & Symes, 2011). Research has shown that children on the AS face peer rejection, for instance, in persisting to narrate about their special interest topics (Dean, Adams & Kasari, 2013). Indeed, research has indicated a high prevalence of bullying and victimisation experienced by children on the AS in inclusive classrooms (Chen & Schwartz, 2012). Self-reports by adults on the AS suggest that social exhaustion is particularly evident in so-called 'cross-neurotype' interactions between individuals on the AS and individuals who are not on the AS (e.g., Crompton, Hallett et al., 2020). Communication breakdowns and difficulties in empathising with one another are also more common in such interactions (Crompton, Ropar et al., 2020; Milton, 2012). These findings highlight the importance of better understanding social interactions occurring in inclusive classrooms where cross-neurotype interactions occur daily. This is also crucial from an educational perspective since schools are expected to support the acquisition of 21st century skills that emphasise students' active participation in studying and the ability to work together (e.g., Hughes, Law & Meijers, 2017).

Prior research on this topic has often zoomed in on individual children and therefore, has rarely considered how social interactions are built *in interacting* with other people (as noted by e.g., Dindar, Lindblom & Kärnä, 2017; Lester, 2015). Interactional challenges in many instances can be a result of a bidirectional difficulty rather than solely attributable as a 'communication deficit' of the individual on the AS (e.g., Milton, 2012). Supporting evidence comes, for instance, from studies in the psychology field that have shown how children on the AS demonstrate better interactional skills in interactions with friends compared to non-friends (Bauminger-Zviely et al., 2014). However, previous research on children on the AS and peer interactions has commonly focused on mapping interactional challenges rather than strengths or understanding what contributes to moments of success (outside structured interventions). It is, therefore, important to consider what counts as successful participation. Hence, considerations on the bidirectional nature of interactional challenges require the use of research methods that can capture the dynamicity of real-life social interactions. Currently, such research heavily relies on the careful moment-by-moment examination of naturally occurring or naturalistic interactions, that is typically focused on analysing one single type of data (e.g., conversation analysis using video data (Mondada, 2016; Heller & Kern, 2021)). Consequently, the current research using video data could benefit from the perspectives provided by multimodality in terms of capturing the interactions through different data types.

Naturalistic research environments

Research is increasingly conducted in naturalistic environments to achieve more ecologically relevant findings. This is highlighted when conducting research with children on the AS, where it is important to maintain the familiarity of the places that the children are accustomed to (Dean, & Chang, 2021; Gangi et al., 2021). Hence, we find in the literature that interventions or observations of children on the AS are progressively conducted in environments that are familiar to the participants, such as schoolgrounds.

Developing research in natural environments is particularly important for some research designs and approaches (e.g., conversation analysis (Heller & Kern, 2021)). In contrast, for some other approaches, such as research with eye tracking devices, studies are more commonly conducted in controlled environments (e.g., Guillon et al., 2014). At the same time, we are seeing an increased interest in research deploying eye tracking methods and measures to complement the understanding of children on the AS' social interaction capabilities and challenges in naturalistic settings (e.g., Edmunds et al., 2017).

Previous eye-tracking research on eye gaze behavior has been based typically on experimental design and focused on presenting individuals with AS static or dynamic representations of social stimuli on a computer screen when assessing gaze (e.g., Guillon et al., 2014; Wilson, Brock & Palermo, 2010). We find the work of Falck-Ytter et al. (2012) as a good initial example of eye tracking methods application to autism research. Falck-Ytter et al. (2012) carried out eye tracking research focused on social attention in children on the AS, having pictures and videos as stimuli to record the gaze of the participants using a static eye tracking system fixed to a computer monitor. The use of eye tracking technology supported the authors to report an existing link between the gaze performance accuracy and the adaptive communication skills of the participating children, which would have been perhaps unlikely to establish without the possibility of assessing subtle eye movements during the task.

However, the use of eye tracking technology is found generally limited to structured research environments using static eye tracking systems, even when the research is developed in a live context, e.g., the experimenter administers a cognitive test to the participant on the AS while the participant's gaze and response are recorded (Falck-Ytter, Carlström, & Johansson, 2015); or the laboratory environment is set to resemble a typical classroom where the participant on the AS is brought in and experimenter reads a story while the participant's gaze is recorded (Falck-Ytter, 2015). Nevertheless, such research has shown, for instance, that children on the AS have a reduced tendency to look at an adult's face during storytelling situation, yet such tendency has not been found to exist in cognitive testing situations with an experimenter, highlighting the importance of understanding the interactional context in which gaze is examined, as well as the affordances of the eye tracking technology even when static.

Recently, researchers have claimed that the traditional laboratory studies focusing on social attention or social gaze have misrepresented how gaze may operate in 'real-world' situations (e.g., Cole, Skarratt & Kuhn, 2016; Hayward et al., 2017) and called for more realistic, ecologically valid eye-tracking research in naturalistic face to face interactions (Chita-Tegmark 2016; McParland, Gallagher & Keenan, 2021). To this, the use of mobile eye tracking devices provides more flexibility to capture participant's gaze regardless of the direction that the person looks at. Whereas studies using mobile eye tracking technology are reported, they are still scarce and often rely on research designs developed within structured laboratory environments, where participants are generally interviewed and or prompted to discuss a topic of interest while wearing eye tracking device (e.g., Nadig et al., 2010; Freeth & Bugembe, 2019). We argue that mobile eye tracking technology affords more comprehensive and objective measures of eye movements compared to estimations made from video recordings, for instance. Hence, this technology could prove a powerful ally during investigations of social interactions in naturalistic environments. In our multi-method research design, we utilise mobile eye tracking technology in a naturalistic education setting to capture information on gazing practices of children on the AS and other peers interacting and collaborating in during a small group work. We believe that one key reason for expanding the research environment beyond the laboratory and for conducting research using mobile eye tracking is to allow the study participants to become active interactants rather than passive receivers of social information as is the case when viewing pictures or videos (see e.g., Gobel, Kim, & Richardson, 2015; Guillon et al., 2014). Broadly, studies using mobile eye tracking technology have been able to examine gaze behaviours in relation to the interactions (e.g., conversational phases (Freeth & Bugembe, 2019)) during which the participants' eye movements have been recorded. However, interactions occurring in naturalistic settings have been rarely explored in detail. Dindar, Korkiakangas et al. (2017) have pointed out how, for instance, an interactional partner's actions have received limited attention in prior research, which has prevented the more contextualised analysis of gaze that could consider how gaze not only reflects social visual attention but is also used for interactional purposes, such as to initiate interaction or to respond to others' initiations (e.g., Gobel et al., 2015; Hessels, 2020; Stivers & Rossano, 2010). Research in the education realm also highly benefits from design-based research carried out in natural contexts as otherwise the results would not properly reflect the complexity of the processes that occur in educational settings (see for instance Barab & Squire, 2004).

Role of children on the AS in research

Research on AS has been dominantly expert-driven and non-participatory (Pellicano, Dinsmore, & Charman, 2014). There has been increasing concern about disconnection between researchers and participants on the AS, as well as research findings and educational practice. The voices of the participants have been neglected during knowledge production (Milton, 2014). Therefore, this has been called to change (Milton, 2014; Pellicano et al., 2014).

Participatory research strategies include the voice of the participants in the different stages of the research: from conception and design of a study, implementation, data collection to contribution of the results (Cornwall & Jewkes, 1995; Gowen et al., 2019; Keating, 2021). Recently, consultation with participants on the AS and their caregivers during different stages of research has increasingly been used to promote the active involvement of the participants and practical benefit of the research outcomes (Fletcher-Watson et al., 2019; Keating, 2021). For instance, Crane et al. (2019) explored young people on the AS' experiences of mental health problems and their perspectives on the support they sought. The researchers and young adults on the AS collaborated in an equitable and fruitful research partnership in all stages of the research process. Current topical question is how to engage people on the AS who are not easily adjusted to a participatory research design, including people with communicational differences, intellectual disability, and young children on the AS (Fletcher-Watson et al. 2019; Lebenhagen, 2020). We argue that involving children on the AS in the role of research partners would empower them by emphasising their contribution to the research that they are participating in, while at the same time would facilitate the translation of findings into practice to further develop strategies to implement in inclusive classrooms. In our research design we implement the video-stimulated account (VSA) method, bringing the children on the AS and their peers as research partners for the examination of eye tracking and camera recorded video material. This method allows the researchers to gain the participants' perspective on the studied phenomenon and include them in the research process (Theobald, 2012; Pihlainen, 2016).

METHODOLOGY - MULTIMODAL DATA COLLECTION

Theoretical frame

Theoretically our research design approach relies on *multimodality of interactions* and *social constructionism,* emphasising the role of interaction in how our social worlds are constructed. Multimodality is recognised as a pluralistic term that has been used in different disciplines to assert different epistemological perspectives (see for instance Mondada, 2016). From a perspective inspired by computer science, Mondada (2016), points out that multimodality refers to channels, mediums and interfaces used for communication; whereas from a social interaction perspective, multimodality is visible through the various resources that people use to interact, including gestures, gaze, language, body posture, etc. These considerations pave the road towards our definition of multimodality in terms of data collection for our study, as *the plurality of procedures, devices, and mediums deployed to capture the richness of social interactions*. Here we see multimodality of data paired to the multiple data sources that may spring from social interaction encounters. In our work, these encounters are contextualised to groups activities in an inclusive educational environment, where children on the AS and their peers interact towards completing a collaborative task.

The social constructionism frame of our research design poses the premise that people construct knowledge through social interactions (Zuriff, 1998). Our study focuses on educational contexts within the grounds of the classroom and the larger environment of the school, where we try to capture the emergent flow of interactions among students. Going a step further on the construction of knowledge through social interactions, we find that *symbolic interactionism*, as proposed by Blumer (1986), serves as a solid basis to understand the construction of social behaviour. Social interactionism sees meaning as social products defined through the activities that results of *people's interactions*, and in turn the meaning is further modified through the experiences the individual encounters. The meaning *something* has for people is the basis for their behaviour towards that *something*. (Blumer, 1986). In the case of our multi-method research design, we take the stand of the micro social constructionism perspective to bring new insights into autism research, educational practices and beyond.

Methods

Drawing from the premise that several sources of mixed data enhance the validity of the study results and support the researchers to gain a more comprehensive view the phenomenon under investigation (Ammenwerth, Iller, & Mansmann, 2003), we use the theory of triangulation in our multi-method research design. Triangulation has been broadly defined as "the multiple employment of sources of data, observers, methods, or theories" (Bednarz, 1985) used combined to research the same phenomenon, fostering a richer understandings and deeper dimensions of interpretations (Jick, 1979; Greene & McClintock, 1985).

Our methodology draws on a participatory approach and emphasises the children's contributions (Kärnä et al., 2010) as well as people on the AS' contributions (Fletcher-Watson et al. 2019) to the research. The goal of the proposed multi-method research design is to develop understanding and strategies to support the social participation of children on the AS within inclusive classrooms. Through our research design we aim to provide an approach to identifying the moments of interactional success among children, focusing on understanding how these emerge and how they could be supported. To holistically capture this phenomenon, we combine mobile eye tracking technology with video recording technology. We argue that this contributes to the development of novel, ecologically more valid eye tracking research that locates the gaze movements in their interactional contexts. With these data collection methods, we gather excellent data that then serve as stimuli to involve children as research partners through VSA discussions. Figure 1 shows the multi-method and data interrelation in our research design.

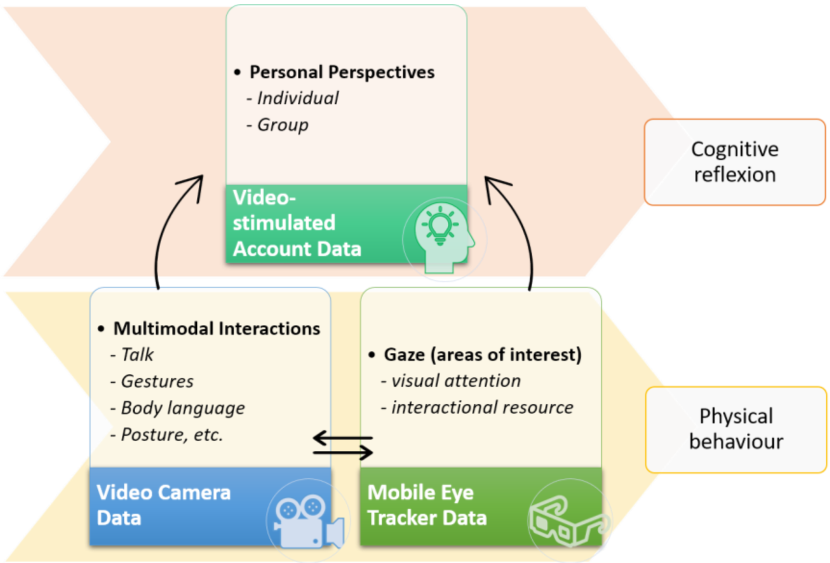


Figure 1. Data collection methods and data types

Mobile eye tracker data – the use of eye tracking technology in autism research and as an emerging educational technology tool (Arslan et al., 2022) is increasing as it can provide a more objective measure of children's eye movements compared to estimations made from video recordings. In particular, mobile eye tracking technology can provide better affordances in terms of capturing the participant's gaze regardless of the direction of their faces or their body posture. Our research design is one of the few using mobile eye tracking technology in a naturalistic school setting with children with AS (McParland, Gallagher, & Keenan, 2021). With this research design we expect to gain information on such gazing practices that have not been accessed before as the classroom and the social interactions can be seen as they unfold in front of the eyes of each individual participant.

(Wide-angle) video camera data – video cameras are a well-known technology for data collection in autism research in education (Arslan et al., 2022). Particularly, video recordings are used in qualitative coding and conversation analysis (CA) methods, which are relatively common in autism studies investigating social interactions as part of mixed methods research design (e.g., Rendle-Short, 2019) or as qualitative research studies (e.g., Tuononen et al., 2016; Doak, 2019). Drawing on conversation analysis (CA), in our research design, the data collected through video cameras facilitate a multimodal interaction analysis (Stivers & Sidnell, 2005) and captures group data to support the understanding of how each individual interacts and collaborates with their peers. Furthermore, the video recorded data complement the eye tracker technology data by providing the context of the gaze behaviours (Korkiakangas, 2018, p. 5) in a stream of action that can be observed from the group's dynamic perspective.

Video stimulated account (VSA) data – discussions through VSA provide opportunities for children on the AS and children without autism to influence and participate actively in the research. During VSA sessions, children participate in analysing video-recordings, from video cameras and/or mobile eye tracking devices, by accounting them in semi-structured interviews with the researcher (Theobald, 2012; Theobald, 2017). Our research design enables children´s active participation that is realised in two levels: first, children have authority to verbalise thoughts that they choose voluntarily, and second, children have control in pausing, repeating, and choosing the order of the video extracts to analyse during VSA sessions (see Ruusuvuori, Nikander, & Hyvärinen, 2011; Theobald, 2017). In this study, children also chose individually one video clip that they will watch together and account later with their peers in a group VSA session. The VSA sessions are video recorded to retroactively complement the analyses of the eye-tracker and video recorded data collected.

From the researcher perspective, the combination of these methods can foster deeper and wider insights into the understanding of how (successful) interactions happen in inclusive educational environments, looking from the individual child's physical behaviour to the group's perceptions of the observed behaviour (see Figure 2).

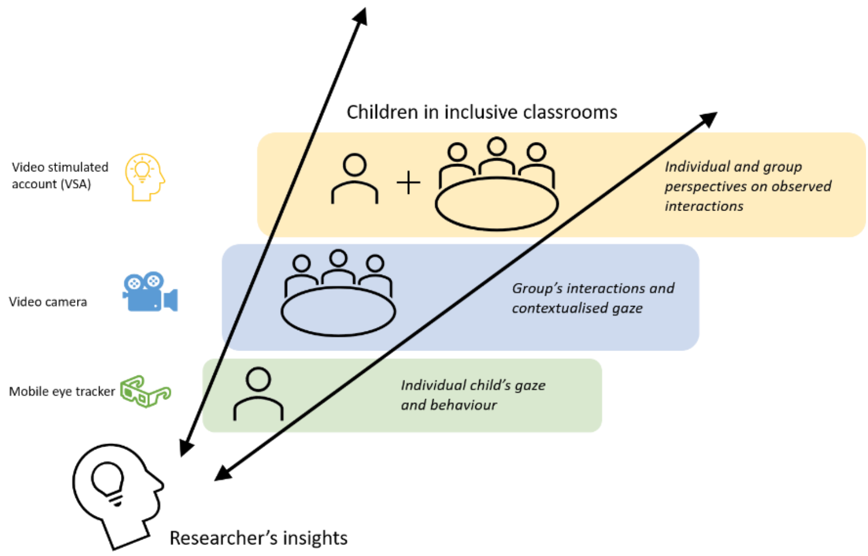


Figure 2. Widening insights through multimodal data collection

PRACTICAL IMPLEMENTATION

Planning

The deployment of a research design based on multimodal data collection started with the careful planning of the activities and tasks to be carried out. As a part of the planning process, we discussed with a group of adults on the AS in Finland issues related to conducting research in school environments. This group provided expert-by-experience views on how to make the data collection procedure as autism-friendly as possible for children, from their perspective. To this end, we carried out a preliminary workshop of 2,5 hours with four volunteer adults on the AS where we discussed the research plan and research design to be deployed at school classrooms, consent forms' wording and survey structure to be sent to parents, among other topics. After the discussion, the volunteers had the possibility to comment the outcomes of this workshop, including a revised research design and consent forms. Based on this process, we updated the research design procedure to include a video description of the activities that will be carried out during the sessions (teacher showed video to the children before the data collection sessions), a section in the survey where the parents could describe their child's preferences and characteristics, as well as a consent form for children. The input from the discussions with the volunteers also offered us the opportunity to revise our protocols so that distractions from the equipment were minimised in the research setup.
In terms of devices' set up, for each data type we created check lists to follow before, during, and after the data collection session with the group of participating children. The check list for each data type collected included the setting of the devices before the data collection section (e.g., for the mobile eye trackers this included verifying that the battery was charged, establishing the connectivity to the software interface and updating the memory card; for the video camera this included verifying the memory card and that the camera was turned on); as well as the data transfer protocol after the session was completed (e.g., storing the collected data in a secured external hard drive and preparing the devices for the next session whenever applicable). In order to minimise errors during the data collection sessions, a researcher took care of preparing the devices for one data type collected. Therefore, in the classroom during the data collection session there were three researchers present, one researcher in charge of the mobile eye tracker data, one researcher in charge of the video cameras and audio data and one researcher in charge of interacting with the children during the development of the collaborative tasks.

A piloting workshop meeting among the researchers was carried out before the data collection sessions with the children. During the piloting meeting all the participating researchers synchronised their work and made sure that they understood their tasks before, during and after the data collection sessions with children. The piloting meeting provided the opportunity to revise the protocols and check lists accordingly. A script was prepared to introduce the participating children to the researchers that would be present with them during the session as well as to the different devices and their function. In this way, we expected to familiarise the children with the devices placed in their classroom so that the situation was as natural as possible to them. The script was also rehearsed during the piloting meeting.

An important part of the planning was the recruiting of schools with inclusive classrooms and obtaining the consent to participate from the parents or guardians and teachers, as well as the assent to participate from the children themselves during the first research session. Two schools were recruited first obtaining approval from headmasters and then obtaining parents' consent to participate. One school was recruited contacting parents of children on the AS via associations' e-mail lists and then asking teachers' and headmaster's willingness to participate in the research.

Participants

Twenty-nine children (age 10-12 years, 4^{th}-5^{th} grade, eighteen males) participated in the data collection. The children in each group had studied together in same class from six months to six years, thus they were familiar to each other. Three children had official AS diagnoses (APA, 2013; WHO, 2019), two with Asperger syndrome, one with pervasive developmental disorder, unspecified (PDD-NOS) with note "Autism Spectrum Disorder" (according to the WHO, 2019). Five children showed autistic traits (as assessed by the Autism Spectrum Screening Questionnaire (ASSQ)) or some other official neurodevelopmental (ND) diagnosis (WHO, 2019). Twenty-one children did not have either AS or other ND diagnosis, nor they had autistic traits as assessed by ASSQ.

Data collection sessions

The multimodal data collection sessions were carried out in Spring 2020, Autumn 2020 and Spring 2021, due to interruptions in the schedule caused by the COVID-19 pandemic. The data were collected from 3 different schools, two in Eastern Finland and one in Southern Finland (see Table 1).

Table 1. Data collection sessions

Activity	Classroom 1		Classroom 2		Classroom 3	
	Spring 2020	Autumn 2020	Spring 2020	Spring 2021	Spring 2020	Spring 2021
Sessions (45 mins)	1	8	1	7	5	20
Sessions/day (total number of days)	2 (1 day)	2 (4 days)	1 (1 day)	1 or 2 (5 days)	5 (1 day)	4 or 5 (5 days)
No. groups	2	2	1	2	5	5
Children/group*	3	3	3	3	3	3
Mobile eye tracking data	1 session	7 sessions	1 session	7 sessions	5 sessions	20 sessions
Video camera data	1 session	8 sessions	1 session	7 sessions	5 sessions	19 sessions
Individual VSA data	-	5 sessions	-	6 sessions	-	15 sessions
Group VSA data	-	2 sessions	-	2 sessions	-	5 sessions
Metadata (feedback on research design)	6	20	3	20	14	59
*In classrooms 1 and 3, the same children participated in both years, but one child dropped out of the study in 2020 after two sessions. In classroom 2, two children who were participating in Spring 2020 dropped out in Spring 2021 due to group change. Five new participants from this classroom were recruited in Spring 2021.						

Each mobile eye tracker data and video camera data collection session was structured as follows:

	Time (mins)	Activity description
Before the session	30	Devices' setup, video cameras positioning, mobile eye tracking system assembly
During the session	1-2	Welcome to the session, introduction to researchers and equipment
	3-5	Mobile eye trackers setup on participants
	10	Introductory game (ludic task planned by the researchers)
	25	Group work (curricular task planned by the teacher)
	2-3	Feedback form collection (metadata)
After the session	15	Initiate data transfer and devices' setup

Video stimulated account (VSA) sessions were carried out about two weeks after the mobile eye tracker and video recording data were collected. Each VSA session (individual or in group) was structured as follows:

	Individual (mins)	Group (mins)	Activity description
Before the session	15	15	Devices' setup, video cameras positioning
During the session	5	5-10	Welcome to the session, introduction to researcher
	5-20	15-30	Watching video clips
	5	-	Watching eye-tracking video and discussion
	2	5-10	VSA session feedback
After the session	15	15	Initiate data transfer and devices setup

The sitting arrangements for the participating groups of children varied according to the facilities of their classrooms but whenever possible the groups where mixed (see Figure 3 and Figure 4).

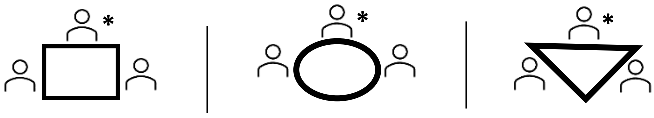


Figure 3. Sitting arrangements during mobile eye tracker and video camera data collection sessions. The * shows the child on the AS (or with AS traits or other ND diagnosis). Left) classroom 1; centre) classroom 2; right) classroom 3

Figure 4. Sitting arrangement around a circular table in classroom 2. The picture shows the technology devices (video cameras and mobile eye trackers) used and other common items in the classroom environment. PEICAS© 2023

Video stimulated account (VSA) sessions were carried out about two weeks after the mobile eye tracker and video recording data were collected. In the remaining manuscript we focus on presenting the feedback received from the mobile eye tracking and video recording use in the research design.

Ethical considerations

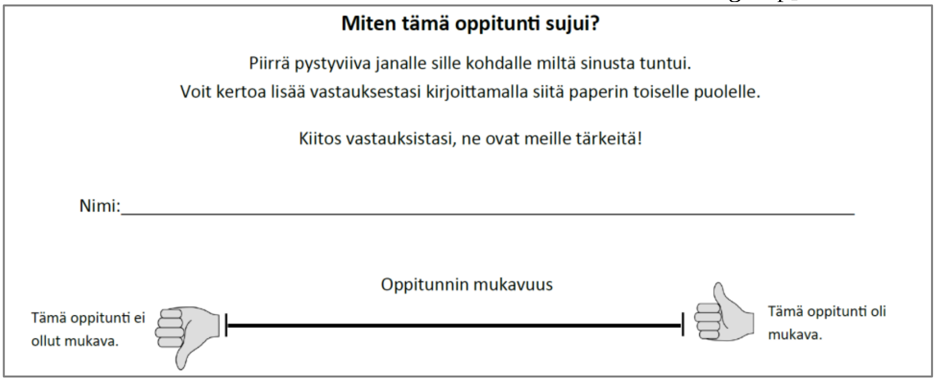
Privacy is a key matter in the project. All data collected is considered private and highly confidential and it is not used for purposes outside the research study before prior written consent from the participants or their legal guardian. The research protocols were also approved by the Ethical Committee of the university.

CHILDREN FEEDBACK ON RESEARCH DESIGN

Due to the novel character of the research design, we wanted to investigate how the children saw the set up in their classroom, whether it was invasive or distracting for them. Therefore, we used a feedback mechanism inspired by the Child Session Rating Scale (CSRS) (Low, Miller & Squire, 2014), to collect the participating children's opinion on the research design including the lesson structure and the naturalness of the classroom environment. CSRS, used in clinical and therapeutic work with children, served as the basis for presenting the scoring of the research questions given to the children. The questionnaire contained 4 items, measured with a 100 mm scale (0 and 100 at the extremes) where children could mark the place that best described their experience (see Figure 5):

a. Lesson comfortability
   [this lesson was not comfortable ________________ this lesson was comfortable]
b. Research equipment (mobile eye tracking glasses, cameras, etc.)
   [the research equipment bothered me ________________ the research equipment did not bother me]
c. Normality of the lesson
   [this lesson did not feel ordinary ________________ this lesson felt ordinary]
d. Group participation

[it was hard for me to work in this group ———————— it was easy for me to work in this group]


Miten tämä oppitunti sujui?

Piirrä pystyviiva janalle sille kohdalle miltä sinusta tuntui.
Voit kertoa lisää vastauksestasi kirjoittamalla siitä paperin toiselle puolelle.

Kiitos vastauksistasi, ne ovat meille tärkeitä!

Nimi:________________________________

Oppitunnin mukavuus

Tämä oppitunti ei ollut mukava.

Tämä oppitunti oli mukava.

Figure 5. Feedback form excerpt. (English translation: How did this lesson go? Mark on the line the point that represents how you felt. You can tell us more about your answers on the other side of the paper. Thank you for your answers, they are important for us! Name: _______ Lesson comfortability: left) this lesson was not comfortable; right) this lesson was comfortable?

At the end of feedback form were one or two open questions: *in what kind of situations it is the easiest for me to be/work with other classmates*? and *what else would you like to say to the researchers?* The first question was asked after the first research session only. The second question was asked after each session.

We analysed n = 122 collected feedback using descriptive statistics due to the small number of samples. The analysis included averages (Avg.) and standard deviations (SD). Data analysis and graphs were made with IBM SPSS program. The extracted scores from the feedback forms were divided in five groups according to the position of the children's marks on their printed sheet: 0-20 mm = *totally agree with the negative statement*; 21-40 mm = *somewhat agree with the negative statement*; 41-60 mm = *neutral*; 61-80 mm = *somewhat agree with the positive statement*; and 81-100 mm = *totally agree with the positive statement.* We divided the data according to the following diagnosis groups: children with no diagnosis; children with other neurodevelopmental (ND) diagnosis; and children on the AS (with diagnosis). The results are presented here for each item in the form.

Lesson comfortability
In terms of how comfortable the lesson felt, most of the received feedback (over 80%) indicated that the lesson was comfortable for the participating children (see Figure 6). There were no differences in averages among the diagnosis groups. According to the standard deviation (SD) evaluations from children without diagnosis had the highest variability.

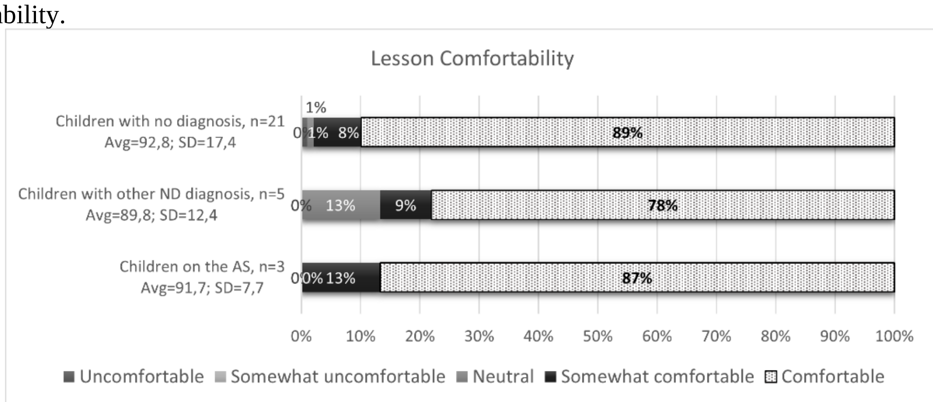


Figure 6. Feedback on lesson comfortability

Research equipment obtrusiveness
The feedback indicated that in over 70% of the cases the research equipment was unobtrusive (Figure 7). Average differences are observed among diagnosis groups. These differences may suggest that children on the AS experienced the research equipment as more obtrusive than other children, while children with other ND diagnosis evaluated the obtrusiveness of research equipment the same as the children without diagnosis. Standard deviations (SD) within groups were over 25 points in all groups.

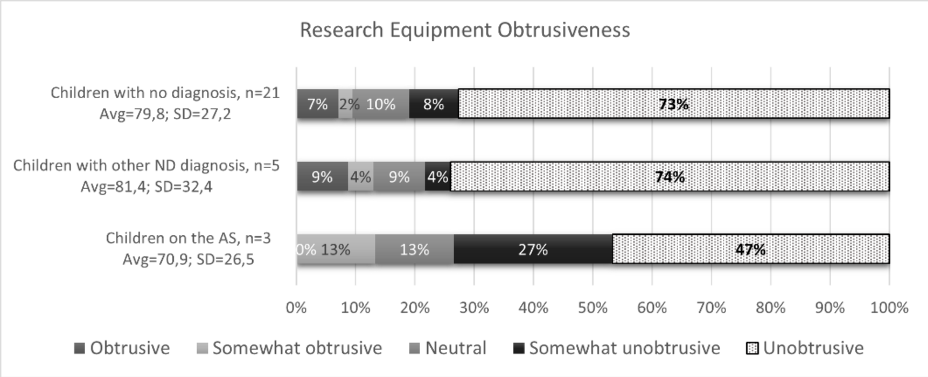


Figure 7. Feedback on how obtrusive the research equipment was from the participants perspective

Normality of the lesson

According to the received feedback, each group perceived the normality of the lesson differently (Figure 8). Observable differences existed in averages among the groups: children on the AS evaluated the lessons as less ordinary than the other two groups, whereas children with no diagnosis reported mostly neutrality towards how normal the lesson felt. Children with other ND diagnosis, however, experienced the lessons mostly as ordinary, but the standard deviation (SD) among this group was higher than in the other two.

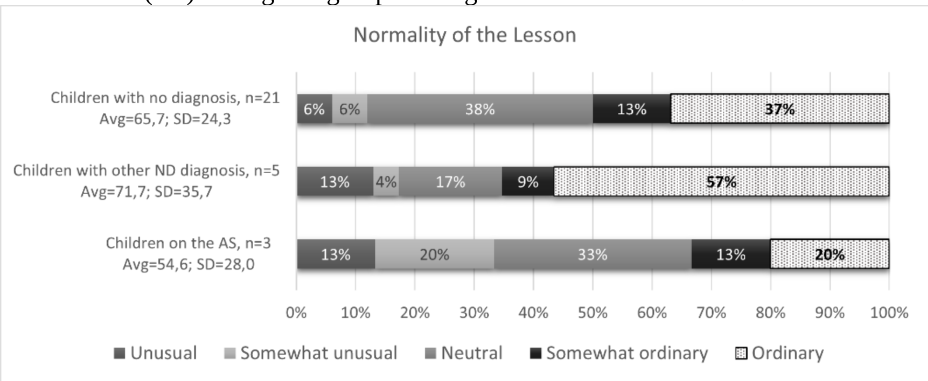


Figure 8. Feedback on how ordinary the lesson felt during the session

Group participation

The feedback received indicated that children felt it was easy for them to work in their group (Figure 9). There was very little difference in averages and deviations within diagnosis groups.

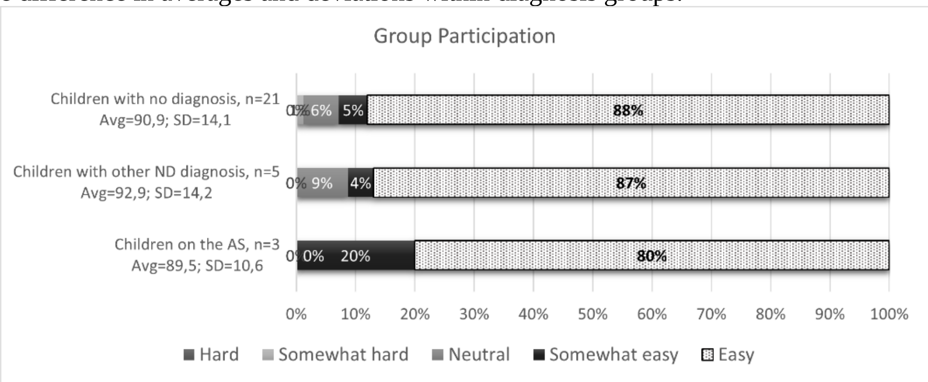


Figure 9. Feedback on easiness of group work

Open questions

Concerning the question: *in what kind of situations it is the easiest for me to be/work with other classmates?* children replied as follows: in games (n=8), groupwork (n=3), math (n=3), all things (n=2), easy things (n=1), storytelling (n=1), do not know (n=4). One child with other ND diagnosis wrote that he preferred to work alone. Differences in answers among diagnosis groups were not observed, but members of the same triad often answered in same way. In the *open feedback* question, children wrote the most frequently that the session was “nice”, “funny”, “a good lesson” (n=13) or greeted/thanked the researchers (n=7). Two children without diagnoses also mentioned that eye-tracking glasses were distractive or annoying. 19% of the received evaluations included open feedback answers, though none from children on the AS

Overall feedback

We looked at the evolution of the received feedback evaluations by session for each group to observe how the participants perceived the sessions as they progressed. For this, we analysed the first and last sessions evaluations independently and grouped together the evaluations received from all middle sessions (**Figure *10***).

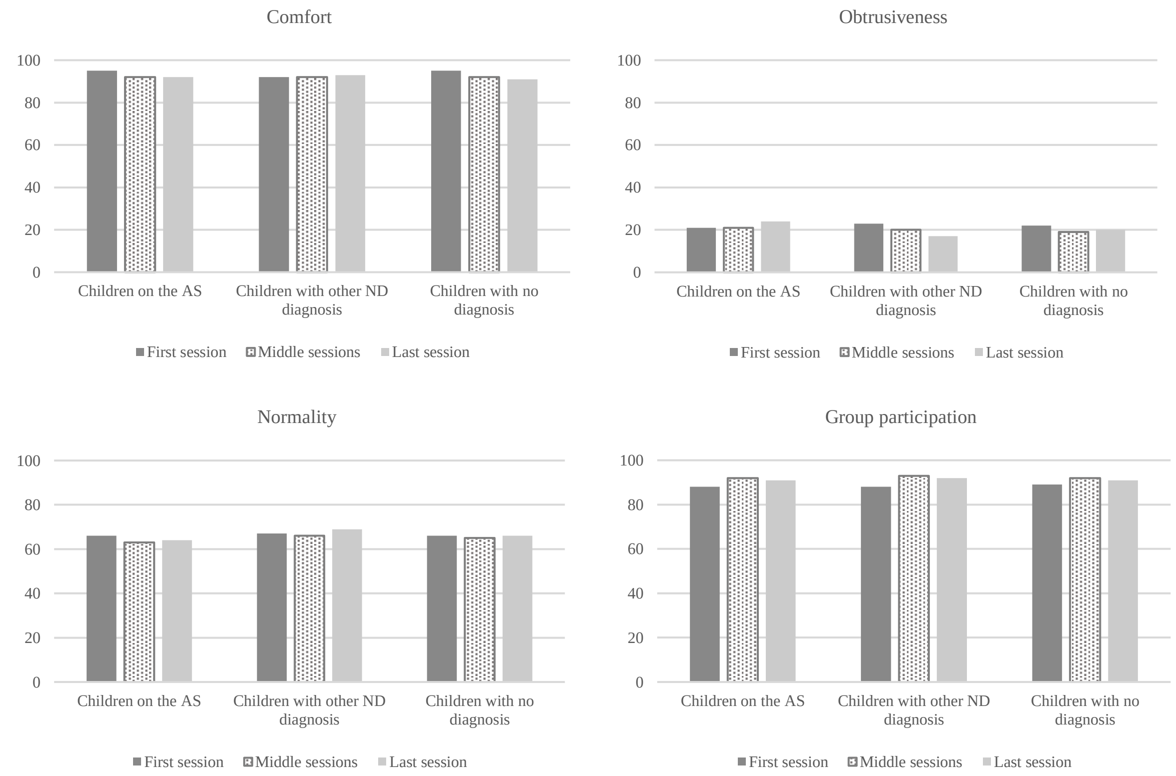


Figure 10. Children's perceptions on the different aspects of the multi-method research design deployment

In general, all children found the research equipment unobtrusive during the lessons, with the group of children with other ND diagnosis reporting to experience the research equipment as less obtrusive as the sessions progressed, compared to the other two groups (**Figure *10***, top right). The perception of comfort (**Figure *10***, top left) and normality (**Figure *10***, bottom left) did not change much as the sessions progressed. In terms of group participation, all children reported increased group participation as the session progressed (**Figure *10***, bottom right).

DISCUSSION AND CONSIDERATIONS

In this work we introduced our methodology for deploying multi-method research with inclusive groups of children using multimodal data collection mechanisms. Feedback form evaluations indicated that children felt the lessons during data collection sessions comfortable, the research equipment mostly unobtrusive and their participation in their group easy. Perhaps not surprisingly, the feedback indicated that the lessons were not fully ordinary, for the most part. Nevertheless, the deviation from the average within each group was over 15 points for the perceived equipment's obtrusiveness and lessons' normality, and over 7 points for the perceived comfort and group participation during the lesson. This indicates that the children tended to experience the research sessions differently.

In general, children on the AS felt that research equipment was more obtrusive and lessons less ordinary than children without diagnosis did. It is reported that people on the AS have hyperreactivity to sensory input and prefer sameness (APA, 2013), thus paying attention more easily to changes in their environment, which is perhaps what we observed here. From the social constructionism perspective, we can consider the social interactions that occur in the classroom as an event that each participating child has their own *discourse* about, since a discourse goes beyond language use in that it refers to a set of meanings, and representations, and viewpoints that together form an individual's version of an event (Burr, 2015). For some, social interactions would perhaps be a pleasant activity that is effortlessly, even unconsciously, carried out throughout the school day and in different scenarios (e.g., at

lunch, at recess, at the classroom). For others, social interactions would be more difficult and even frightful endeavours, better to be avoided. Yet, the children's self-reported perception in the feedback form regarding comfort and the easiness of participation in their small group work was high for all during the research sessions.
In addition, during the VSA sessions, children were also asked to describe their experiences in wearing eye-tracking glasses (research equipment) and participating in groupwork as a part of research activities. Some children on the AS mentioned that they were used to wearing regular glasses daily so changing them to eye-tracking glasses did not differ much from their routines. When compared to regular learning in a classroom, the participating children on the AS and classmates (that is, children without any diagnoses and children with diagnoses other than AS) stated that video-recorded groupwork sessions were quieter because there were less children in one space. Only one 12-year-old boy on the AS stated that the cameras made them more cautious of the way they talk to each other because *"we don´t want to watch [people] arguing for half an hour [in the video]"*. This child suggested for further studies to hide the cameras better so that children do not pay much attention to them. Using VSA method the children on the AS as well as their classmates were included not only in data collection but also in data analysis. Rather than utilising researchers' definitions for interactional success, this multimodal data collection research design tries to involve all the participating children to consider means to enhance successful interactions among themselves. Through this we highlight the socially situated nature of the activity of 'seeing success' (see Pilnick & James, 2013) and how it is construed in interaction with others.

Recommendations
Based on the outcomes of our work we can put forward the following recommendations when deploying research in inclusive education environments:
Using a participatory research approach. In support of previous reported works in the literature, in our research approach we also found enormous value in including the autistic community impressions in the development of the research design during the planning stage (e.g., through discussions with volunteer adults on the AS). We argue that the resulting research design reflected well the impressions collected on how the technology setup could be unobtrusive for children on the AS and increase the familiarity of the children with the research procedure even before implementing it. Therefore, it is a good strategy to implement a participatory research design agenda when collecting data in inclusive educational environments.

Supporting comfort of participation. We observed that children were familiar with one another, which might have facilitated their small group work and their comfort during the research session. Furthermore, children were encouraged to discuss with the researchers how the equipment felt for them during the setup, which fostered an open, flexible and relaxed atmosphere throughout the sessions. Moreover, since the children were involved in the research process as *active experts*, i.e., discussing their views with the researchers and freely providing their opinions particularly during VSA sessions and during the evaluation of the research implementation after each session, this perhaps encouraged the children to feel more comfortable with the research implementation as the sessions progressed. Therefore, we consider it to be an important strategy to build an atmosphere of trust during the research implementation to facilitate the children's comfort during participation. This could be achieved, for example, through deploying several data collection sessions with the same children over a period of time.

Facilitating groupwork. Besides children's familiarity with one another and with the environment, it is important to provide a relaxing atmosphere where the children can work together. In the case of our research design, this was achieved through allocating time (10 minutes of the research session) for a ludic task that the group needed to complete. This strategy is also in line with children's views that it is easier for them to be/work with other classmates, for instance, through games.

Limitations
A validity limitation in this kind of self-rating approach is that some people on the AS tend to underreport emotions or have difficulties evaluating their emotional states (Sebastian, Blakemore & Charman, 2009). For instance, in this research, some participating children always produced the same evaluations; one child on the AS confirmed this verbally to the researchers. Although this can mean that they experienced the lessons in the same way every time, a repetitive answering style can also indicate that self-evaluation was difficult for them. Furthermore, since the children on the AS did not voluntarily provide any open feedback, this kind of mechanism might not be ideal to collect their impressions and opinions or perhaps they would need more time and/or a quieter space to focus in order to provide open feedback. Furthermore, due to the relatively small number of participants it is not feasible to generate relevant statistical analysis from the collected data. In addition, it is important to notice that the children on the AS that participated in our study were verbally capable and could interact with neurotypical peers in their small work group during the research sessions. Therefore, different mechanisms for collecting the views on the research design would be needed when involving minimally verbal children, which is an important step for the future research. Nevertheless, although the research design is very complex, as a multidisciplinary effort bringing

together computer science, educational science and psychology experts, the feedback that we received in general indicates the ecological validity of the data collected through this design for the inclusive educational setting of the study. That is because most of the children felt comfortable enough to behave and interact in a way that was natural to them, which afforded the capturing of real-life interactions. These results could represent with high fidelity the situations that could arise in an inclusive classroom as compared to collecting the data in a laboratory setting.

Conclusions

In our research, we set out to understand how successful interactions in inclusive educational environments occur – this paper contributed with a research design implementation that captures the processes through which such a contextual definition of *successful interactions* could be attained with the direct input from the participants. The combination of these methods can foster deeper and wider insights into the understanding of how successful interactions happen in inclusive classrooms, looking from the individual child's physical behaviour to the group's perceptions of the observed behaviour (see Figure 11). The data captured through this multi-method research design will be jointly analysed towards shedding light on children's interactions in inclusive educational environments. Our work has implications for the educational technologies research community wishing to carry out investigations in inclusive educational settings.

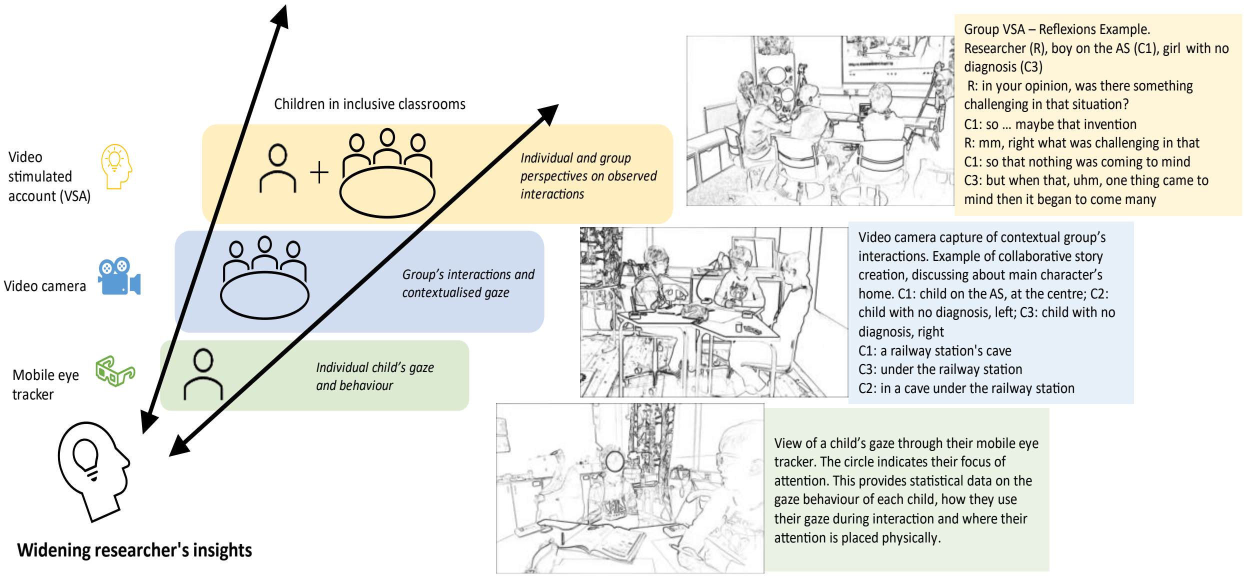


Figure 11. Contribution of each data type to widen the researcher's insight in our multi-method research design. PEICAS© 2023

ACKNOWLEDGEMENT

We thank the participants in the study. This research was implemented with the support of Academy of Finland grant number 324641.

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