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Using a lens of awareness in phenomenographic research: an example from early mathematics education research

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ABSTRACT

This paper aims to contribute to the advancement of methodological practice for phenomenographic research by introducing the notion of a *lens of awareness*, as a device that can enable researchers to zoom into the detail of the research process (the parts of the whole) and out again to the related context of a phenomenographic study (the whole). The lens enables researchers to embrace a reflexive stance to bracket prior assumptions, allowing critical inspection of the whole research process and a thorough retrospective and transparent account of the approaches used. We use a *lens of awareness* to communicate the component parts of a study that examined preschool children's understandings of the use of numerals in everyday environments. Through an analytical documentation of processes and decisions, we examine challenges, the powerful affordances and application of a phenomenographic approach to research with young children. We discuss four strands of researcher awareness that we argue are important in the application of phenomenography: the nature of the phenomenon; the operationalization of phenomenographic theoretical notions; the researcher's versus the participant's experience of the phenomenon and the applied research processes. The paper closes with explorative strategies that may enhance transparency and trustworthiness in phenomenographic research.

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Introduction

Phenomenographic research focuses on how research participants experience or interpret a particular phenomenon differently. A phenomenon is viewed through the research participants' awareness of it, their experiences and relationship with it (Marton and Booth 1997), and not through the eyes of researchers or broader society. Consequently, phenomenographic researchers make statements about other people's experiences of the world, employing a second order perspective to see the world through the eyes of people experiencing it (Marton 1981).

Part-whole relationships in our awareness of any particular phenomenon are emphasized, distinguishing the phenomenon from its context as well as differentiating its parts, the way they relate to each other and to the whole (Åkerlind 2018). Phenomenographic studies aim to uncover an interpretive, collective experience of a phenomenon which is based on a context-sensitive awareness rather than the beliefs of the collective. The findings of phenomenographic studies depict the qualitatively different meanings that people communicate about a phenomenon, discovered

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through the data analysis process, as a set of *Categories of Description*. The ways in which categories of description are related to each other are depicted in an *Outcome Space*. The *Outcome Space* is often presented as a diagram or Table and embodies the structural relationships that underpin the categories of description (Åkerlind 2012). For education, examining variations in how learners think about different phenomena is essential, as such evidence can inform decisions on what is to be learnt and also inform the design of fruitful pedagogical approaches that build on learners' existing understandings.

Recent literature reveals extensive debate about the methodological practices of phenomenography, particularly variations in processes used by researchers (Tight 2016), and the rigour of its application (Stolz 2020), with calls for more detailed accounts of the research process (Cope 2004, Durden 2018, Harris 2011). Rovio-Johansson and Ingerman (2016, p. 264) note that 'any research approach must continually sustain a methodological discussion to retain vitality'. They observe that more focus has gone into discussions of variation theory, which is dependent empirically on a previous phenomenographic study (Åkerlind 2018), while the phenomenographic basis is often taken for granted.

We aim to respond to these calls for a detailed account and methodological discussion of the phenomenographic process, by zooming into the research decisions and analysis processes of a recent study, illuminating the application of a phenomenographic approach to data collection and analysis, critically reflecting on the challenges that we encountered but also the opportunities that emerged. Finally, we offer a series of observations and strategies that may provide guidance for future phenomenographic research.

In 1997, Marton and Booth elaborated a theory of awareness, where learning is defined as a change in awareness. Part of a phenomenographic study is to unpack 'how different patterns of awareness of some component parts and lack of awareness of others is associated with the different ways of understanding the phenomenon found within the group' (Åkerlind 2018, p. 950).

The paper aims to make a methodological contribution by proposing that, applying an analogous notion of awareness to unpacking the component parts of a phenomenographic study and relating it to the whole, can lead to a robust, trustworthy, and transparent account of the research. As researchers, we experience the phenomenon of undertaking phenomenographic research and interpret this phenomenon through our awareness of it, our experiences and relationship with it. To be clear, we are not referring to awareness in terms of learning; rather, to awareness of the research process as a phenomenon, with us as researchers doing and experiencing the research. We introduce a *lens of awareness* as a device that can enable researchers to zoom in to the detail of the research process (the parts of the whole) and out again to the related context of a research project (the whole). The lens embraces a reflexive stance to bracket prior assumptions, allowing critical inspection of the whole research process, potential sources of non-objectivity, theoretical perspectives, and a thorough retrospective and transparent account of the approaches used.

In this paper, we use this suggested *lens of awareness*, to address calls for transparency and trustworthiness in phenomenographic research, intentionally picking apart four strands of our study: the nature of the phenomenon under consideration, the operationalization of key theoretical notions, the researcher's expectations versus the participant's experience, and detailed documentation of methodological processes.

Phenomenography research literature is also vocal in calling for more research to develop the phenomenographic methodology, to move it forward and encourage robust discussion (Tight 2016). Much research has been carried out in higher or secondary level education. We found very little research with young children. The methodological discussion presented here is based on research that explored qualitative variations in how preschool children perceive the social uses of written numerals in everyday life. Using this study as an example, the focus of the discussion is on the methodological processes and not on presenting the empirical findings in depth, which are reported elsewhere (Voutsina and Stott 2023). We aim to unearth and share insights that can inform phenomenographic research more broadly, beyond the context of the study we use as example. Furthermore, through discussion of our research design which involved children in the

collection of visual data from their own everyday experiences, we intend to contribute methodologically to the application of a phenomenographic approach to research with young children.

Methodological issues

A phenomenographic study is distinctive in two ways: First, through an iterative analytic approach, it centres on discovering the range and variation of collective interpretations and reported experiences, not one single understanding. Second, the analysis organizes the participants' experiences into an ordered list of categories with documented relationships between these categories. These relationships are depicted in the outcome space; a 'map of the collective mind' (Orgill 2012, p. 2609).

These characteristics make credibility and replicability complicated. Marton (1986, p. 35) argued against replicability, indicating that identifying the categories of description is a 'form of discovery, and discoveries do not have to be replicable'. An increasing diversity of interpretations and understandings of phenomenographic ideas has led to variations in practice and in definitions of terms, both regionally (for example, differences in approaches in Sweden and Australia) and from study to study (Dringenberg 2015). Durden (2018) highlights the need to strengthen the validity of phenomenographic studies. He proposes that one way to achieve enhanced validity is to conceptualize the external horizon, which enables the phenomenon under study to be 'distinguished from its context and background' (Marton and Booth 1997, p. 87), as a 'separable entity' (Durden 2018, p. 20). He argues that including this in research design 'reveals aspects of conceptions that may not be easily revealed otherwise' (Durden 2018, p. 20) and can thus contribute to the validity of phenomenographic research, by enabling informed scrutiny of results.

Collier-Reed *et al.* (2009) argue that trustworthiness, which has been proposed by Lincoln and Guba (1985) as an alternative to positivist ideas of validity, reliability and objectivity, for determining the value of interpretive research, is a vital part of establishing rigour and should apply to the entire process of phenomenographic research. We refer readers to Collier-Reed *et al.*'s (2009) work for a detailed explanation of how the component notions of trustworthiness, that is, 'credibility', 'transferability' and 'dependability' are operationalized in phenomenographic research and the proposed measures for each. In the following sections, we discuss four strands of researcher awareness that we argue are important in the application of phenomenography. Under the first two strands, 'the nature of the phenomenon' and 'the operationalization of phenomenographic theoretical notions', we address issues linked to 'content-related credibility', defined by Collier-Reed *et al.* (2009, pp. 7–8) as relating 'to a researcher having a comprehensive grasp, or understanding, of topics related to the phenomenon under investigation.' Under the third and fourth strands, 'the researchers' versus the participant's experience of the phenomenon' and 'the applied research processes', we address issues related to 'credibility of method' (Collier-Reed *et al.* 2009, p. 8), by discussing the nature of the sample, our approach to the interview design and bracketing. In our discussion, we consider dependability 'as a function of the interview conversation' and 'as a function of accuracy of transcription' (Collier-Reed *et al.* 2009, p. 10). In addition, by presenting a comprehensive and transparent account of different phases in our applied analysis processes, we address issues related to dependability 'as a function of analysis', including our operationalization of *dialogic dependability checking* 'as a basis for assuring dependability of results' (Collier-Reed *et al.* 2009, p. 10).

At the beginning of our research, we felt the phenomenographic research process lacked clarity as the research literature provides limited explicit guidance on how to carry out phenomenographic research and operationalize the key underpinning theoretical notions. Harris (2011) concurs, noting that it is unusual for researchers to communicate how data collection tools were created specifically for gathering phenomenographic data or for detailing the step-by-step analysis process.

To address this need, in the following sections, we first present our approach to defining phenomenographic concepts as they apply to our study of preschool children's conceptions of the social use of written numerals, before detailing the applied methodological process and how the above-mentioned components of trustworthiness were addressed.

The nature of the phenomenon

The theoretical underpinning of phenomenography is the idea that individuals are aware of phenomena based on their own perspective of the situations they experience and our 'experience of the phenomena is modified, transformed, and developed through the situations we experience them in' (Marton and Booth 1997, p. 83). For this study, the phenomenon of focus was the use of written numerals in everyday life, encountered on vehicles, packaging, the street, in homes, digital displays and shops; denoting order, quantity and measurement-related ideas as well as labels/identifiers. Our research interest concerned young children's experienced world and lies in the range of interpretations they have of the meaning and purpose of these written numerals, based on culturally shared understandings and rules.

Dringenberg (2015) suggest that the nature of the phenomenon can vary widely along what could be thought of as a continuum, from specialized, concrete concepts such as price (Lo and Chik 2016) and force (Tan and Tan 2020) to abstract and broader notions. Broader phenomena are not bounded by subject- or domain-specific correct or authorized conceptions, in the same way as, for example, the phenomenon of force is in science. Examples include the nature of types of information systems (Cope 2004), the experiences of being a university researcher (Åkerlind 2005) or the nature of teaching and learning in science (Taylor and Booth 2015).

For our study, we were aware of how the nature of the phenomenon we studied is unlike any of these phenomena, in that it is not restricted to a specialized learning domain. This is because we focused on discovering how children perceive the varied meanings that numerals represent outside the context of arithmetic, and the social use of numerals in life, beyond their computational use. In everyday life, written numerals may convey messages that have mathematics-related meanings, such as quantity, measurement, order, or not, such as using numerals as identifiers on buses, buildings, or t-shirts.

Thus, we saw a challenge in the nature of the phenomenon itself. Written numerals on everyday objects and contexts (with or without a mathematics-related meaning) are bounded by broader socially and culturally accepted rules. Therefore, in the context of our research, we considered the use of written numerals in everyday contexts as a 'conceived and experienced sociocultural phenomenon' (Voutsina and Stott 2023, p. 251).

From an early age, children learn about the culturally agreed ways that written numerals are used and what they mean through interaction with those numerals, older siblings, adults, and cultural and social contexts. As our phenomenon is based on culturally shared understandings and rules, we adopted the practice of *reflexivity* (Lincoln and Guba 1985) as an overall approach to our study, allowing us to identify our own preconceptions, take thoughtful measures to lessen their influence on the research process and to document these in detail.

Operationalising phenomenographic concepts

Harris (2011) notes that there is little consistency in how the structure of awareness and specifically the constructs of the internal and external horizons are defined in phenomenographic studies, and a lack of detailed accounts of their application. In this section, we explore these further, before we set out how we defined various phenomenographic concepts in our study. Marton and Booth's (1997) structure of awareness, breaks down individual conceptions of phenomena into referential and structural aspects (Taylor and Booth 2015). The meaning of the conception is the referential aspect; it refers to *what* individuals experience, the meaning that individuals assign to a phenomenon. The structural aspect refers to *how* individuals experience the phenomenon; it involves 'discernment of the whole from the context on the one hand and discernment of the parts and their relationships within the whole on the other' (Marton and Booth 1997, p. 87). The structural aspect of a phenomenon is defined by the internal and external horizons.

The fluid *object of focal awareness* comprises any aspects of the phenomenon that are simultaneously held in focal awareness in any *one instance*. Marton and Booth (1997, pp. 98–99) highlight that these aspects relate to the internal and external horizons in both ‘an instantaneous, snapshot mode and in a fluid, dynamic mode’ and may be replaced by another object of focal awareness combination from instant to instant, as we cannot be ‘aware of everything in the same way’ all the time. In any moment, we are marginally aware of most things. Then the situation changes and with it the structure of our awareness. Something else will come to the forefront (as the object of focal awareness) surrounded by aspects from our experiences and others will move into the margins of awareness.

The terms *structure of awareness*, and *internal and external horizons* are explicitly defined for our study as follows. Tolchinsky (2003, p. 98) argues that children are exposed to written numerals in everyday environments from an early age and that ‘looking at numbers, attending to their names, perceiving the ways in which they are commented’ on, are very real experiences. We hypothesized that the children in our study would have a wide range of different experiences regarding numerals in their environments, depending on the nature of the everyday activities that they engage with. The structural aspect of children’s awareness may be depicted as shown in Figure 1.

The *internal horizon* (the series of smaller ovals in Figure 1) includes the digits of the written numeral, the object on which it appears plus any currency or measurement symbols accompanying the numeral. It may also include the size, colour and shape of the object, from a child’s perspective. A child’s experienced world (i.e. the aspects that are related to the object of focal awareness, the context in which the numeral is embedded and the context of situations in which numerals are used) will vary, depending on the child’s previous experiences. These constitute the *external horizon*. The second component of the external horizon is the margins of awareness (shown as a thick oval in Figure 1) which includes anything not related to the object of focal awareness by context or meaning (i.e. aspects that children are marginally aware of or have not yet experienced).

An example of the structure of awareness is shown in Figure 2. This image was used in photo-elicitation interviews with children and depicts a 40 numeral on a speed sign. The range of aspects that are simultaneously held in focal awareness in any instant (the object of focal awareness), may shift the internal horizon. If the child simply recognizes the numeral but does not express awareness of

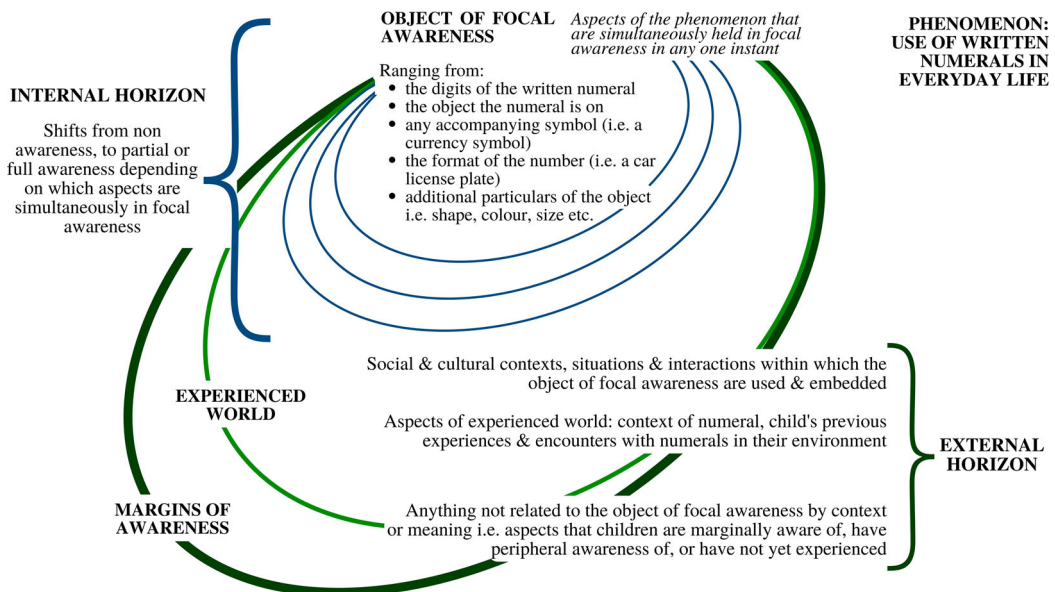


Figure 1. The structure of awareness for our study (adapted from Marton and Booth 1997).

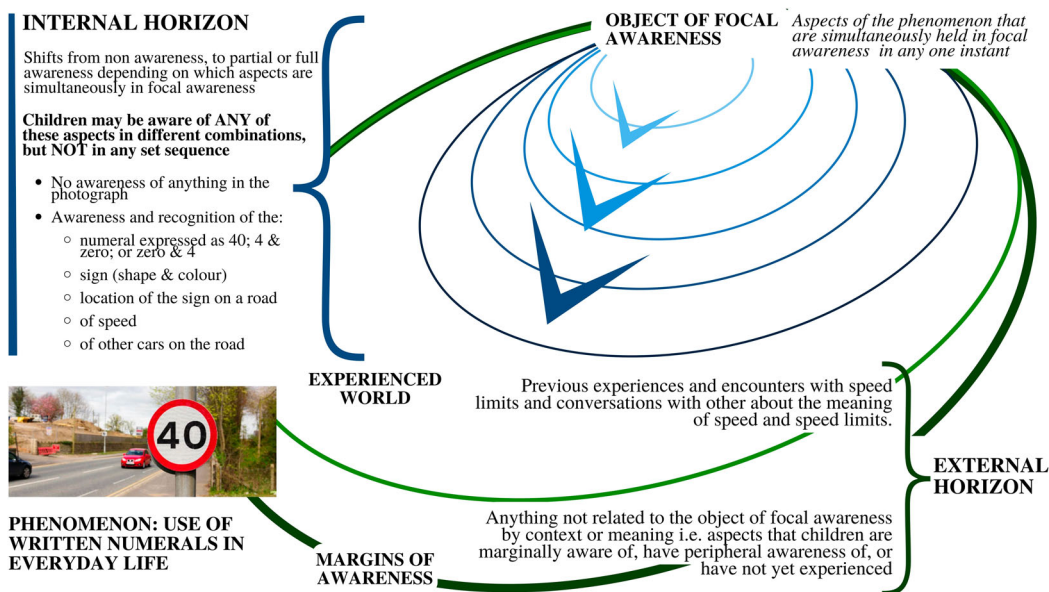


Figure 2. An example of structure of awareness for a written numeral signifying speed.

the object which the numeral is on or the context of the situation, the internal horizon is small, and the gap between it and the external horizon is wide. The internal horizon shifts closer to the experienced world (external horizon) if the child recognizes and expresses that the 40 is on a road sign and gives a message to a driver. If the child is aware and expresses that it means you can drive at 40 miles per hour on this road in your car, more aspects are held in awareness simultaneously (the numeral, the sign, the road and the meaning of speed). As children's experiences of speed expand, the margin of awareness, for this instance of awareness, shrinks.

Methodological processes

We kept a detailed record of the research processes we undertook and research decisions we made with regards to the interview process, transcriptions, and analysis. We updated our document after every analysis session to reflect on our progress and to refer to, both during the analysis and for the purposes of communicating our research and findings. This became a key tool in enabling our lens of awareness.

Interviews

Our design aimed to bring children's experiences closer to the centre of the research by including and exploring the written numerals that appear in their own, varied environments. The volunteer sample of 37 preschool children aged 3–4.7 years (with a mean age of 4.01 years) came from 28 different nurseries and preschools located in two cities in the South of England. The children and their families were invited to play a 'Number Spotting' game, taking photographs of written numerals in their day-to-day environments, which they sent to the research team.

To preserve the child's voice and own experiences of numerals, we used a photo-elicitation approach (Pyle 2013) in subsequent one-to-one, video-recorded interviews with the children, using the children's own photographs of numerals as the basis for the discussions where possible. These photographs were supplemented, if necessary, with images from a photograph bank selected by the researchers, to provide a broad spectrum of numerals that communicated ordinal position, various types of measurement, numeric labels, and quantity. The set of photographs used were

different for each child's interview, adding a level of complexity to our data and analysis which we discuss below. In selecting photographs before the interviews took place, we were offered a glimpse into the child's experiences of written numerals in the environment and could begin to create a bridge between our adult, culturally accepted interpretations of the phenomenon and what the child saw around them, allowing us to consciously initiate the process of *bracketing* our presuppositions.

As is common in phenomenography (Green 2005), we used semi-structured interviews to collect data. The interview protocol had several different opening scenarios for how children might initially respond to the numerals they saw in the photograph. We asked questions such as: What do you see here? Do you know the name of this number? What does this number tell us? Why is this number useful to us? Why do we need to have this [number] there?

Bracketing

As noted, phenomenographic data collection and analysis is viewed as a process of discovery (Marton 1986). Ashworth and Lucas (2000, p. 297) caution that this 'must be grounded in the lived experience of its research participants', and that steps must be taken throughout the research to deliberately put aside anything that leads away from the participant's experience, and which may affect results. This is known as *bracketing*. Stolz (2020, p. 1080) notes that bracketing, prevents attitudes, beliefs, assumptions and opinions from 'distorting an experience into an experience of another kind'.

Due to the nature of our phenomenon, this was one of the most significant aspects to address throughout the research process and in our account of the research. Here, we refer to the steps we took throughout the interview process to address this. We revisit this further in both the Analysis and Discussion sections.

During the interview process, we acknowledge that we expected ourselves to surrender much of our own embedded knowledge of the purposes of written numbers in cultural contexts and our assumptions of what is culturally accepted. Therefore, we employed empathetic bracketing in the interviews to engage in a nuanced way with the young children's described experiences, thus stepping back from our assumptions of the accepted or authorized conception of written numerals and to allow an unprejudiced exploration of the child's lived experiences of written numerals.

The first author adopted an open, engaging, and curious approach to interviewing each child, using the following strategies to engage with the child's experiences in the moment of conversation and to consciously bracket her own knowledge of the phenomenon. Firstly, in adopting a non-judgemental stance, all responses from the child were accepted as they were given. No judgements were made on anything the child said about a numeral or the purpose of a numeral, and the child was not corrected in any way. It takes effort to stay silent when children express things in ways that do not resonate with our adult experiences. However, being reflectively aware that this was important, the first author refrained from attempting to rephrase what children said based on her own understanding of the meanings of written numerals (Ashworth and Lucas 1998). Where possible, the researcher used the numerals or words expressed by the child in follow up questions. For example, if the numeral in the photograph was 36 but the child said 63, the interviewer used 63 in follow up. Or she repeated what the child had said and asked further clarifying questions as shown in this example:

- Child: Eight.
 Researcher: Show me. OK, so eight? What is that? [indicates the lollies on the image]
 Child: Popsicles
 Researcher: Popsicles. So why is that 8 written there?
 Child: Because it was the popsicles with the sticks!
 Researcher: Because it was popsicles with the sticks, OK.



Secondly, the interview protocol was flexibly structured for the children to express themselves from their perspective, enthusiastically sharing what they knew about the numerals, jumping in to talking about what they saw in the photograph before the interviewer had the chance to ask questions. If the child did not offer a verbal response, further follow up questions were based on what the child said or expressed nonverbally.

Thirdly, careful listening and attention was given to the words and nonverbal actions used by children and assumptions were not made about their meanings even if they seemed obvious. From a curious stance, follow up questions were often asked to clarify the child's intended meanings by relating a question directly to the child's experience (i.e. asking them about their own house number and why it is on their house) or asking them to share more about experiences that they had mentioned, for example talking about the number on their own birthday cake.

Although many of the strategies we used in the interview for bracketing are used in research with older children and adults, we suggest the notion of openly and *empathetically immersing* (Ashworth and Lucas 2000) ourselves in the child's experiences from data collection and throughout the interview process is essential when working with younger children, not only to create a connection with the child and to establish trust, but also to consciously put aside one's own preconceptions and knowledge.

Transcription considerations

Both theoretical and methodological issues arise when considering how audio and video recordings will be translated into data. Barron and Engle (2007, p. 28) argue that a transcript cannot be value-neutral, nor is there a complete transcript that 'captures the full complexity of all verbal and nonverbal events', stressing the importance of explaining how the transcription was created to suit the needs of the research project. In phenomenography, the transcription must accurately reflect the emotions and emphases of the participant (Ashworth and Lucas 2000, p. 304) and must include 'anything that is likely to affect the interpretation of meaning'.

The first author transcribed all 37 transcripts, verbatim, based on both audio and video recordings of the interviews, thus immersing herself in the data and beginning the analysis process (Orgill 2012). The first challenge we encountered here was how children of this age express themselves using both verbal and nonverbal communication. Using both forms of recordings to search for meaning in responses (Herbert and Pierce 2013), we sought to provide as much detail as was necessary to maintain integrity with the child's response, including gestures, head movements, body language and disengaged actions such as crawling under the table. These provided clues to the child's degree of engagement, adding to the meaning behind their responses. Even though we did not separately analyse the child's nonverbal communication, we constantly referred to these to support our interpretations. Including the nonverbal aspects that children employ to convey thoughts they do not have words for, gave us insight into the points where the child was not able to verbally express themselves fully, enabling us to access as much of the expressed awareness as possible. Transcribing nonverbal communication from video-recordings is time consuming but we saw both the process of transcribing (as immersion in the data) and the transcripts themselves as important parts of our analysis process.

The second challenge was identifying and separating the responses to different types of numerals shown in photographs. Rather than numbering each line in the script (which is a common convention), we followed the structure of the interview by numbering and including a thumbnail of each photograph in the transcripts next to the conversation between the child and the interviewer. Due to the recursive nature of the analysis process, devising a system to track the variety of numerals shown in photographs in the transcripts and in analysis was imperative, in being able to reference a fragment back to an individual script.

Analysis

Han and Ellis (2019) present some useful guidance on the *phases* of the analysis process, pointing out that there is no singular agreed procedure for how to analyse phenomenographic data. Utilizing their iterative phases of data preparation, familiarization, dialogic dependability checking, contrasting, grouping and sorting, the analysis process stretched over a period of 17 weeks from start to finish as summarized in Table 1.

Due to the complexity of our transcripts with regards to the different types of numerals, we began the process of familiarization with two scripts, which we gradually increased to six over the first eight weeks. From weeks nine to 12 we worked with 30% of the scripts, and small sets of two to three were added until week 16.


Discovering interpretations in a small dataset

The question: ‘what does this response tell us about this child’s understanding of the meaning and purpose of this written numeral in the environment?’ initiated our discovery process. Both authors read the first two randomly selected transcripts several times to sensitize and familiarize themselves with the data (Ashworth and Lucas 2000), before undertaking a joint analysis session. For each photograph in the transcript, we first noted if the child had responded verbally to the prompts. If they had, we ascertained if the numeral (part of the phenomenon under consideration) had been recognized.

The numerals shown on photographs used in the interviews were typically on an *object* and had a *context* (surroundings, when and where the photograph was taken etc.). The internal horizon includes the digits of the written numeral, the object on which it appears, and, if appropriate, any symbol accompanying the numeral. The external horizon is the cultural and social contexts within which written numerals are used, as well as any previous experiences the child has of numerals. The next step was to determine if the child recognized and / or referred to the object and /or symbol accompanying the numeral; recognized and / or referred to the context of the numeral. Focussing on the way children expressed their awareness in different combinations with regards to these elements, enabled us to begin the search for those dimensions that vary, differentiating how one conception was different to another. Clarity on the shifts in internal horizon (no awareness, partial or full awareness of the dimensions of context and object and symbol) came later in the process, as discussed below.

Response extracts (which we call fragments) were written on sticky notes, with identifiers of the child, the type of numeral and position in the script. The notes were placed randomly on flip chart sheets (Figure 3) and sticky notes¹ were loosely grouped as differences and similarities arose, engaging with the c processes outlined by Han and Ellis (2019). An anonymised example of a grouping that we initially named ‘Explicit meaning aligned with context and object’ is shown in Figure 3.

Table 1. Overview of 17-week analysis process.

Phase 1 	Phase 2	Phase 3	Phase 4
Data preparation and immersion in data	Dialogic dependability checking and analysis	Full data set dialogic dependability checking	Finalisation and documentation of categories of description
Weeks 1–15: Iterative Transcription from audio and video. Verbal and nonverbal data. Thumbnails of interview photos.	Small sets of 3–4 transcripts For each set of scripts added to the pool: • Familiarisation – Individually by each researcher then joint analysis meeting. • Contrasting and unpacking differences, sorting, grouping by similarities.	Week 16 Categories delineated by dimensions of variation. Review coding for first set of transcripts added to the pool. Descriptions of groupings and dimensions of variation edited.	Week 17 Groups named as categories and descriptions finalised. Categories delineated by dimensions of variation.

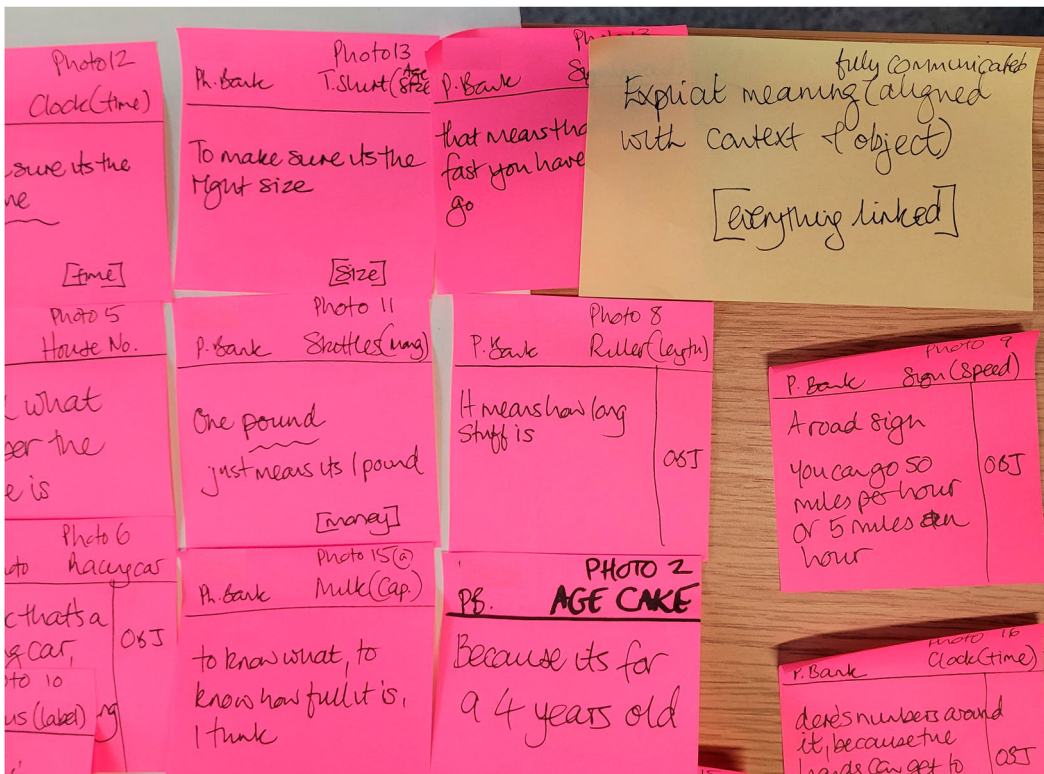


Figure 3. Discovering interpretations in the transcripts (week one).

Data volume challenges

Subsequently, we moved the sticky notes to a digital space called Miro as used by Tan and Tan (2020). The digital fragments were identified to trace them back to the child's transcript, as above. We noted the child's recognition and reference to the object, context and / or symbol in the photograph. The interactive and collaborative environment of Miro assisted in reviewing the fragments and making comments for further discussion.

Over weeks two to seven, we integrated one new script at a time and operationalized our process of *dialogic dependability checking* (Collier-Reed et al. 2009) as follows: each of us engaged with a new script individually, making notes regarding fragments and aspects discussed above. We jointly discussed and mutually critiqued the data until agreement was reached. The fragments were added to Miro, tagged and placed under a group heading (Figure 4).

The focus of phenomenographic analysis is to discover the *collective* interpretations of the sample group, not individual ones (Åkerlind 2012). As fragments from the most recent set of transcripts were added, existing ones were reconsidered and moved around in the context of the new data in the pool. Similarly, descriptive group headings were created, merged, or put to one side. By the end of week seven we had five transcripts in total, and several 'working' group names in this initial sub pool, and the volume of fragments in the MIRO system became unmanageable, so we established codes in NVIVO (a qualitative data analysis tool) that echoed the tags in MIRO. We added the previous five and one new script to NVIVO (now working with a pool of $6 \pm 16\%$ of scripts). Each fragment in the script was tagged with an object, context and symbol code and allocated to one of the preliminary groupings which looked like this at this stage of the analysis (Figure 5).

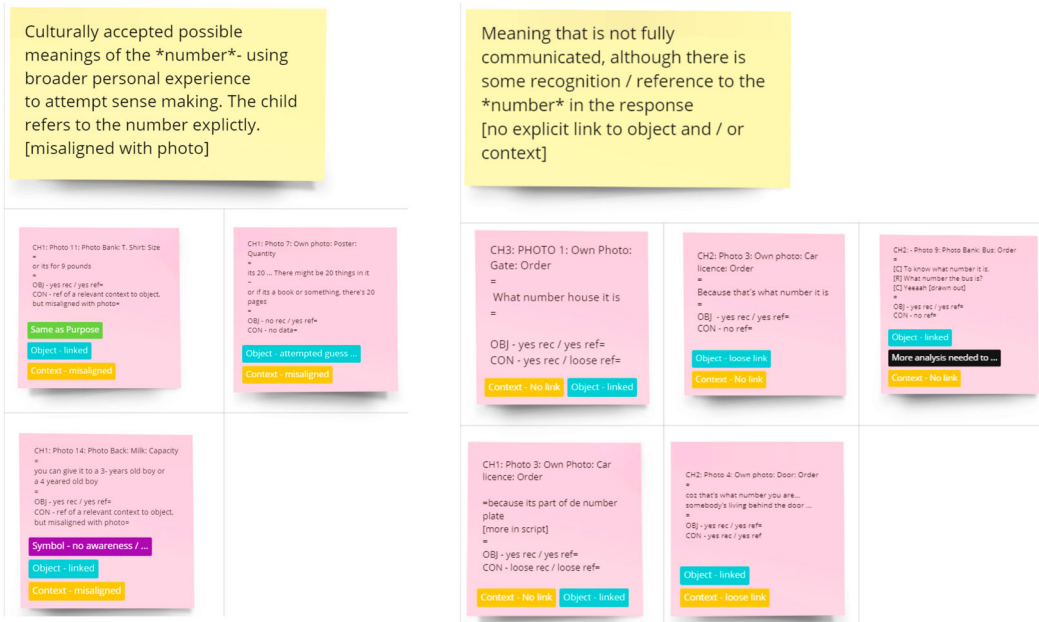


Figure 4. Example of a MIRO board (week four).

Reflecting on the process thus far, we were reassured that we had kept the initial pool of data to a limited number of scripts. This afforded us the opportunity to explore various methods of engaging with and organizing the increasing number of fragments as we worked.

Accounting for the children's accounts of their experiences

New insights arose for us whenever we incorporated new transcripts to the pool, as we went back to the existing scripts and looked at them with fresh eyes, as noted by Bowden (2005). We consciously applied our *lens of awareness*, exercising what Bowden calls (2005, p. 27) 'conscious vigilance', repeatedly zooming into the detail of individual scripts and out into the broader pool. In adding further transcripts to the pool, we encountered one of our principal challenges. Many children could identify the numeral(s) they saw, but could not articulate what they were on, what the context of the numeral in the photograph was or what the meaning and purpose of the numeral was. The range of responses we now saw in the transcripts increased in range, reflecting silences to 'I can't remember'; 'I don't know'; hesitating words, like 'hmm', 'err' combined with a nonverbal

1. No expressed meaning and / or purpose of number
2. No number-focused meaning and / or purpose
3. Meaning and / or purpose misaligned object and / or context in photo
4. Generalised meaning and / or purpose linked to the object but misaligned with context
5. Meaning and / or purpose not fully expressed but in line with cultural rules
6. Fully expressed meaning and / or purpose, in line with cultural rules, implicitly drawn from symbol
7. Fully expressed meaning and / or purpose in line with culturally shared rules
8. Examples provided, fully expressed meaning and / or purpose in line with culturally shared rules

Figure 5. Snapshot of preliminary groupings at week seven (Research Decisions document, 09-09-2021).⁵

response like head shaking, to lengthy explanations of children's experience of a written numeral and articulated explanations of the meaning and purpose of it.

We considered how to account for these different experiences of written numerals in young children. As Marton and Booth (1997, p. 112) explain, 'the variation between different ways of experiencing something, then, derives from the fact that different aspects or different parts of the whole may or may not be discerned and be objects of focal awareness simultaneously'. We saw that if children were able to discern and hold aspects of the number(s), object and symbol and the immediate context in focus, they could express their experience of the *meaning* or *purpose* of the numeral. If their response suggested limited discernment of the various parts, we considered these as variations in experience.

One issue noted in the phenomenographic literature is how researchers maintain a second order perspective in the collection, analysis and reporting of data and findings. It has been argued that phenomenography equates 'participants' experiences with their accounts of those experiences' (Orgill 2012, p. 2610). Apart from the responses where there was silence or lack of engagement, given the age of our sample, we saw the types of responses noted above as data to be included in our analysis. We were guided in this by Marton and Booth's (1997) observation that the categories should be complete in that nothing in the collective experience (of the sample under investigation) is left unspoken.

Two groupings arose that are worth noting, those numbered as 3 and 4² in Table 2 below (in each extract, R represents the researcher and C represents the child). What might be a misalignment with the example of a number and what is culturally accepted about its use (from an adult's point of view) allowed us to capture how a child's broader, existing experience of the world informs their undertaking to interpret and express meaning. These allowed us to acknowledge the existing, accepted cultural understandings of the reality of written numerals in the environment whilst at the same time recognize, value, document, and account for how the children's broader experiences allowed them to make reasonable educated guesses even if not aligned with the culturally shared³ experience.

Fluidity in discovering the groupings

This extract from our Research Decisions document, illustrates the fluidity of our analysis process:




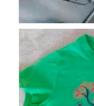




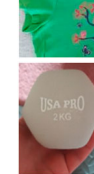
We found it increasingly complex to allocate a child's response to a preliminary grouping for the meanings of house and bus numerals, as there were surprisingly lots of different ways children were expressing meaning / purpose for these numerals. (Extract from project Research Decisions document, 27th September 2021, week 11).

The responses to *different types* of written numerals, for example, on photographs showing bus and house numbers, prompted us to check consistency in allocating children's verbal responses across groupings. A temporary new grouping of expressed meaning was created called: 'Recognition of labelling function', described as: *From the response, it appears that the child recognizes that the numeral has a labelling function, but the purpose of the numeral is not expressed.*

We added further small sets of transcripts to the pool in weeks 13–15 and applied the same joint iterative dialogic dependability process to each new set. Once all the transcripts were included (week 16), we conducted a full data set dialogic dependability process, looking for inconsistencies across the groupings, particularly revisiting the first set of six transcripts. This paper-based process considered the complexity of the range of different numeral uses and meanings portraying quantity, identifiers (buses, car licence plates) and signifying measures (e.g. time, speed, money, length).

In week 17, we documented our results in final, stabilized categories of description, mindful of the criteria proposed by Marton and Booth (1997) for quality of the set of categories, where each category should reveal something distinct about the way of experiencing the phenomenon; each of the categories have a logical relationship with each other and the number of categories should be as parsimonious as is reasonable to capture the variations in the data. We developed our

Table 2. Categories of description with sample data extracts.

Categories of Description: Children's expressed meaning and / or purpose of numerals	Extract examples and photograph showing the numeral in context <i>R</i> represents researcher; <i>C</i> represents child	
1 No expressed meaning and / or purpose of numeral.	R. Why are there numbers on the clock? C. Because, because ... that's the office.	
2 Description of actions associated with the context and object, rather than number-focused meaning and / or purpose of numeral.	R. Why do you think that number is there. C. Because it says someone to go.	
3 Meaning and / or purpose of numeral misaligned with object and context.	R. What are those numbers there in the kitchen for? C. Because it's safe, for mommy. R. Why is it safe for Mummy? What do the numbers tell her? C. Um ... um ... don't touch them.	
4 Meaning and / or purpose of numeral linked to the object but misaligned with context.	R. Why is there a 9 on the t-shirt? C. Because is 40, 40 pounds for kids.	
5 Recognition that the numeral has a meaning and / or purpose, but the specific communicative message of the numeral is not expressed.	R. So why is that 6 there on the bus C. Because that's the number of it.	
6 Meaning and / or purpose not fully expressed but there is expressed recognition of a specific communicative message in line with culturally shared rules.	R. Why is that number 7 on the bus? C. Because when the bus goes at the station, the people know that it's there.	
7a Fully expressed meaning and / or purpose implicitly drawn from symbol accompanying numeral, in line with culturally shared rules.	R. What else could it be? C. Aah, it's one Pound R. How do you know that? C. Because I do.	
7b Fully expressed meaning and / or purpose of numeral in line with culturally shared rules.	R. Why do you think there's a 9 there? C. Coz, it's for 9-year-olds.	
8 Fully expressed meaning and / or purpose of numeral, in line with culturally shared rules, with examples provided.	C. And it's got a 2 on, so she knows what kilo it is R. What ... ? C. Kilo it is. So she knows it two kilos. When she does her exercises, when she wants to pick 3 kilo weights, she picks one with a 3 on.	

outcome space (Voutsina and Stott 2023), by providing category names, comprehensive descriptions and clearly illustrating how each category was different to other categories. In naming the categories, we have purposefully avoided names that may suggest 'experience of numerals as ...'. In doing so, we have aimed to align with Saljo's (1997, p. 178) recommendation that the data should not be approached as a direct record of experiences, but as 'indicative of accounting practices' of phenomena, that is, 'ways of understanding, talking, arguing and in general, ways of bringing the world into language in order to be able to communicate'. The naming of categories considers the extent to which our participants provided responses that communicated fully expressed or not fully expressed meanings. We considered that this was important in our study, which included young children who were still developing their verbal expression. Our approach to this was underpinned by our position that a 'not expressed, or not fully developed expression of awareness, should not be necessarily interpreted as lack of awareness and experience' (Voutsina and Stott 2023, p. 270).

These categories have three important distinctions. First, they are not general characterizations of the phenomenon of the use of written numerals in everyday life but children's ways of expressing these in the interviews (Svensson 1997). Second, the categories represent a map of the *collective range* of different ways, documented through data examples, in which the children expressed their awareness of meanings of numerals in everyday life. Third, the categories are not developmental. That is, they do not depict a developmental trajectory through which children expand their awareness of the meanings and purposes of written numbers. Children do not need to pass through a previous category to reach another. Rather, a single child may express interpretations within more than one category, for different instances of numerals. The categories therefore depict the collective's layers of experience and *expanding awareness* of the cultural rules associated with numerals in everyday situations. The ordering of categories 'indicates the way in which human awareness of any phenomenon collectively unfolds or expands' (Åkerlind 2023, 6).

Discussion

The notions of transparency and trustworthiness act as an overarching umbrella for this section. We draw together four key strands of *researcher awareness* from the account given above: awareness of the nature of the phenomenon; operationalizing phenomenographic, theoretical terms; awareness of the researcher's expectations versus participant's experience; and detailing methodological processes. Each of these strands is viewed through different combinations of our lens of awareness: conscious noticing and vigilance, adopting a curious and non-judgemental stance, engaging in reflection, and careful documentation (Figure 6).

Nature of the phenomenon

One thread running through this paper has been the nature of the phenomenon we investigated. A child's everyday environment is filled with numerals on various objects and to a larger or lesser extent, children will hear and observe older children and adults around them interacting and using these numerals. Tolchinsky (2003, p. 110) observes that the use of numerals represents conventions worked out by people and as such 'social knowledge is embodied in the many cultural artifacts used in daily life and transmitted through social uses.' Written numerals in everyday environments are therefore bounded by socially and culturally accepted rules, learnt through interaction with those numerals, adults, older children, and cultural and social contexts from an early age; our *own* knowledge of the phenomenon is embedded in our own lifelong, everyday experiences. In this case, the phenomenon under focus has broad social and cultural underpinnings in everyday life as well as more targeted learning outcomes across various disciplines, not just early mathematics.

We argue that this is an additional aspect that is *not* addressed in any detail in phenomenography research reports: the nature of the phenomenon that each phenomenographic study focuses on. Dringenberg (2015) touch on this issue in their reflective article. However, we suggest that this

needs to be thoroughly unpacked, and the implications to bracketing and the analysis process documented. Depending on the nature of the phenomenon, phenomenographic studies may differ in their application, practice, design, and methodological assumptions. To achieve a high degree of trustworthiness, phenomenographic studies need to be transparent in how the nature of the phenomenon has influenced the research practice and its application.

Researcher's expectations versus participant's experience

The nature of the phenomenon also pertains to how researchers approach data collection and interpretation of the data through analysis. Åkerlind (2012, 6) notes that the inevitably relational nature of researchers' interpretation of data is an 'important principle in understanding the role of the researcher in phenomenography' and must be addressed in research accounts. Additionally, the outcome will reflect both the data and researchers' judgements in interpreting the data (Åkerlind 2012). As people who live in this social world, we, as researchers, have our own established and commonly accepted interpretations of the phenomenon. We have described how we addressed this in the account above.

Several researchers suggest that the *structure* may be imposed by the researcher, rather than emerging from the data (Åkerlind 2012). In discovering and describing our categories of description, we consciously applied our *lens of awareness* using two practices to ensure we worked from the data as much as possible. First, the meticulous process of gradually increasing the number of scripts under analysis kept our focus on new data and how that affected the data currently in the pool, and second, we attempted to capture both verbal and nonverbal responses from the children to access as much of the children's expressed awareness as possible.

Further, Marton (1986, p. 35) proposes, 'the phenomenographer must discover and classify previously unspecified ways in which people think about certain aspects of reality'. Our intention to include as much as we could of what the child expressed, revealed that each of our categories was distinct in terms of experiencing the phenomenon. We suggest that several of our categories⁴ are examples of *previously unspecified ways* of interpreting the phenomenon of the use of written numerals in everyday life. This is because these categories arose from the data. These were not ways that we as researchers viewed the phenomenon but were expressed by the children as uses related to numbers. Thus, as far as possible, the categories of description reflect the all-inclusive range of ways in which the young children in our study expressed and interpreted the phenomenon of the use of written numerals in everyday life in the interviews.

Finally, employing empathetic bracketing in the interviews was essential for establishing a connection with young children, affording us the space to explore how this phenomenon was experienced by the child, and for distancing ourselves from our own experience of this deeply embedded cultural phenomenon. From the start of the study, using the families' Number Spotting game photographs compelled us to consciously step back from our own experience. As Marton and Booth (1997) argue, this conscious stepping back can be used to illuminate how others talk of, handle, experience and understand the phenomenon.

Operationalizing phenomenographic terms

Phenomenographic research has been criticized for lack of detail and transparency, particularly with regards to how phenomenographic concepts and terms are defined and used. Harris (2011, p. 117) proposed that when the frameworks used in a study are clearly defined, they can be used as tools to provide researchers with a 'way to "think apart" intertwined understandings, processes, parts, motives, and contexts'. We defined and provided concrete examples from our data for the terms structure of awareness, and the internal and external horizons. We suggest that engaging deeply with the concepts and sharing explicit examples of how theoretical terms have been applied in

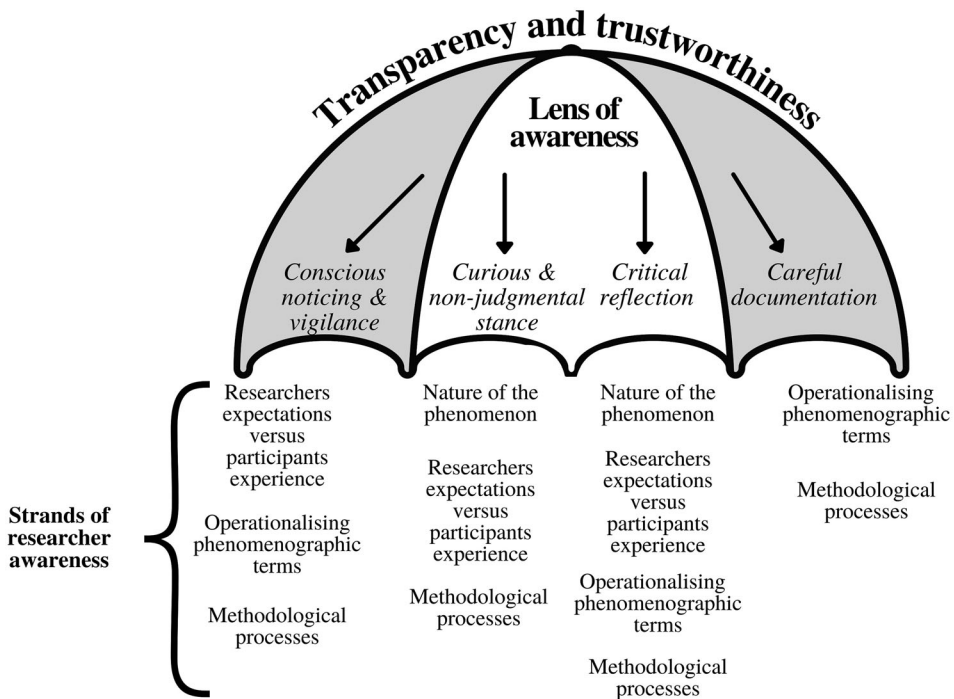


Figure 6. The lens of awareness and strands of researcher awareness.

practice is essential for clarifying how findings are interpreted and how these concepts have been operationalized within the study.

Methodological processes

The specific strategies highlighted below arise from our methodological processes and have enabled us to apply *conscious vigilance* (Bowden 2005) to our processes throughout the research.

- (1) A mindful approach to creating transcriptions, afforded by recording audio and video, allowed us to transcribe both verbal and nonverbal communication, allowing us to discover an unexpected range of responses. The essential aspects of young children’s expression were preserved, meaning the analysis, and the resultant findings, were rooted in the sample’s collective voice, words, and actions.
- (2) Implementing a method to trace a particular fragment back to the original data on the transcript (and to the video if necessary) was important so that we were always able to clarify our understandings of the child’s expressed awareness of their experience.
- (3) Due to the complexity of different variations of the phenomenon with regards to the wide variety of types of numerals shown in photographs, working with small sets of transcripts at any one time, and introducing new scripts gradually, allowed us to zoom in with a lens of researcher awareness, gain new insights, re-frame and expand our understanding of children’s experiences over the course of analysis.
- (4) We formulated deliberate procedures for analysis collaboration, using the iterative process of dialogic dependability checking.

Such strategies could be adapted and used by research, particularly research with young children, that aims to apply a phenomenographic approach with conscious vigilance to methodological processes, enabling researchers to position their analytical lens and interpretations as close as possible to the participants' expressed meanings and experiences.

Conclusion

As researchers, we experience the phenomenon of undertaking phenomenographic research and interpret this phenomenon through our awareness of it, our experiences and relationship with it. Applying a *lens of awareness* to our experience of the phenomenon and to the research process was a key factor in addressing and negotiating how variations in practice manifested in our study, and for grappling with challenges that arose in the analysis phase. This paper has aimed to contribute to the advancement of the methodological application of phenomenography by proposing the use of a *lens of awareness*, for setting out research steps and decisions that can support transparency and trustworthiness in phenomenography. We have shown how we have applied a lens of awareness to a recent study, providing an analytical account of our experiences and interpretations of phenomenographic research. By proposing explorative strategies for conscious vigilance in the application of a phenomenographic approach to research with young children, the paper contributes to methodological discussions and phenomenographic research practice more broadly, beyond the particular example discussed here. Phenomenographic research can be strengthened through reflection on variations in practice, and areas of concern within the discourse, such as defining and giving examples of specific phenomenography terminology, providing a robust description of the research method and paying attention to the minutia of the analysis process.

Notes

1. Approximately 54 fragments from the 2 scripts.
2. Meaning and / or purpose of: numeral misaligned with object and context and linked to the object but misaligned with context.
3. The term "culturally shared" allowed us to distance examples of these from correct/incorrect labelling.
4. Such as those numbered 2, 3 and 4 in Table 2.
5. Please refer to: Voutsina and Stott (2023) for the full discussion of the final categories of description and outcome space.

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Statements and declarations

- The authors report there are no competing interests to declare.
- The research received ethics approval from the University of Southampton, Faculty of Social Sciences Ethics Committee (ERGO II 55474.A1).
- The research followed the British Educational Research Association Ethical Guidelines for Educational Research (2018).

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