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Gesture as data for a phenomenographic analysis of mathematical conceptions

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ABSTRACT

This paper reports on a phenomenographic investigation for which both participant utterances and their gestures were analysed in order for researchers to gain insight into their understanding of the concept of rate. Video-recordings were made of twenty interviews with Year 10 students. Detailed analysis, of both the sound and images, illuminated the meaning of rate-related gestures. Findings indicate that students often use the symbols and metaphors of gesture to complement, supplement or even contradict verbal descriptions. This study demonstrates, in one setting, the efficacy of phenomenography, with attention not only to participants' words but also their gestures, to explore mathematical conceptions.

1. Introduction

Phenomenography seeks to reveal the "qualitatively different ways in which people experience, conceptualise, perceive, and understand various aspects of, and various phenomena in, the world around them" (Marton, 1988, p. 179), for example, the concept of rate in this study. As will be explained below, the aim of phenomenography is to reveal *categories of description*, delineated by the *dimensions of variation* which emerge from the data, and hence structure the categories into an *outcome space*. In published phenomenographic analysis the data is usually restricted to participants' "utterances" (Akerlind, Bowden, & Green, 2005) but we suggest that, at least for some areas of research, more understanding can be captured if gestures are considered as well. This study addressed the question: In a phenomenographic study does attention to gesture add to the researchers' understanding of students' conceptions? This study focussed on conceptions of the mathematical phenomenon of rate.

This paper presents a case study describing the place of gesture as data in a phenomenographic study. Merriam (1988) refers to a case study as "an intensive, holistic description and analysis of a single instance, phenomenon or unit" (p. 21). A case study approach is appropriate because this paper presents an examination of *instance in action* (McDonald & Walker, 1977). The instance here is the employment of gesture in phenomenographic analysis. Consequently, this paper reports on the specific case of the analysis of video data collected to explore the variation in middle secondary school students' understandings of the mathematical concept of rate. It is intended that by utilising this approach a deeper understanding may be gained of specific issues associated with combining gesture with utterances in interview responses for phenomenographic analysis.

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In the sections below, the background literature and conceptual framework are described, and then details of the methods employed in this study are provided. Next results are presented and discussed, and finally conclusions drawn.

2. Background

2.1. Phenomenography

For a phenomenographic study "the validity of the outcomes is related to the processes that are used at all stages" (Akerlind et al., 2005, p. 89) they are: the selection of the sample for maximum variation; the conduct of consistent, open interviews; and the iterative inductive analysis which remains focused on the meanings expressed in the set of transcripts taken as a whole. In phenomenography, categories or themes emerge from the analysis of transcripts rather than the researcher fitting the data to a predetermined model. Typically, transcriptions of interviews are examined to find ways of grouping the participants' responses into *categories of description* according to the features held in common. These features are referred to as *dimensions of variation*. Each category is carefully described in terms of the applicable options within specific dimensions evident in the category.

Meaningful responses relating to the phenomenon are taken from the individual transcripts and pooled, shifting attention from the individual to the meanings expressed by the group as a whole (Marton, 1988). Responses which appear to relate to the same conception are grouped together to form *meaning statements*. These initial meaning statements are fundamental to phenomenographic analysis as groupings of these meaning statements suggest the initial categories. "[C]ategories of description are not intended to necessarily correspond to the perception of any particular individual ... [rather they are an] aggregate of similar perceptions ... [where] texts [are examined] as a group rather than singularity of individual experience ... [so that] any one transcript could contribute to a number of categories" (Akerlind et al., 2005, p. 92). Any particular response statement may only be classified into just one of the categories, but it is possible that different responses from the same participant may be placed in different categories. Phenomenographic analysis requires a series of iterations to refine the categories through repeated reading of the transcripts (Akerlind et al., 2005) and in this case re-viewing of the video data. Consideration of the initial categories, formed from the grouping of the meaning statements, to discern the features of the phenomenon which separate the categories one from another, leads to the development of the initial dimensions. The dimensions establish the underlying structure of the phenomenon. The initial categories suggest the initial dimensions and the data are repeatedly re-examined to refine both the categories and the dimensions. Only categories and dimensions which are supported by the data are included.

As stated above, dimensions are the means by which the categories are distinguished one from another. They highlight the changes in awareness of the critical features of the phenomenon under investigation. More sophisticated conceptions are differentiated from less sophisticated conceptions by the awareness of different or additional values of a dimension or the discernment of more dimensions. The commonalities and differences between the categories are defined by the particular 'values' of the dimensions which relate to a particular category. The dimensions facilitate an ordering of the categories into an *outcome space* where each category is placed in relationship to the other categories indicating the distinct internal logical relationships supported by the empirical data. The categories comprising the outcome space should show a logical structure, in which dimensions of variation can be identified, and the categories should externally cover the data. The hierarchical nature of the outcome space infers that some categories indicate a higher level of perception of the phenomenon in question (Marton, 1988). An outcome space developed through this phenomenographic analysis provides grounds for further research to determine the prevalence of each category.

Whilst it is more common to audio-record phenomenographic interviews, there have been a number of phenomenographic studies using video for data collection (see for example, Aberg-Bengtsson, 1998). Dortins (2002) reported that body language conveyed information not available in the words used in her interviews investigating law students' perceptions of learning and working in law. Similarly Cope (2000) reports that, in his phenomenographic study of learning about the concept of an information system, "body language and voice inflection were lost when the interviews were transcribed. ... This loss of body language and voice inflection makes a phenomenographic analysis more difficult" (p. 201). He recommended that phenomenographic analysis would be improved by video-recording interviews rather than audio-recording, so that during analysis "the transcribed text, body language and voice inflection would be available to the researcher, promoting improved analysis" (p. 201).

2.2. Gesture and mathematics

The importance of gestures, in conveying information regarding students understanding of mathematical concepts, has become the focus of much research in recent years. Based on their study of eight teachers, teaching mathematical equivalence to students of age eight to ten years, Goldin-Meadow, Kim, and Singer (1999) asserted the importance of teachers' gestures in conveying mathematical concepts. Noble (2003) reported in detail on the use of gestures in the development of one student's new mathematical knowledge connecting graphs of motion with their own motion. Sabena (2004), who studied of secondary students understanding of the integral function, also reported that gesture was instrumental to the development of this concept. Similarly, Arzarello, Robutti, and Bazzini (2005) suggested "students' cognitive activity is strongly marked by rich language and gesture production" (p. 64), as the eleven and twelve year olds,