When There Isn't Enough Time For An Interview: How To Analyse Open Assessment Tasks

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This paper describes open assessment tasks and their place in interview-based research. Open assessment tasks are designed to elicit children's understandings and are interview–like in their intent. Responses to open assessment tasks are extremely diverse, and our analysis provides an order that allows inferences about children's understanding to be made. Our experiences to date with this approach indicate that open assessment tasks offer a highly reliable, valid approach to situations where it is not possible to implement interviews.

Introduction

Let it be understood at the outset that we believe the clinical interview has no peer for assessing a child's capabilities in mathematics, particularly their cognitive capabilities. However it must also be said that *interviewing* has severe limitations in terms of time and the skills required of the researcher. Our own research needs have led us to devising a methodology that provides an efficient alternative. Our methodology is based on the use of open assessment tasks.

The open assessment task puts questions to children, in written or oral form, and requires a written, drawn, or constructed response that can be analysed later by the researcher. Unlike a clinical interview, there is no 'next question' to probe further, but to compensate for this, there is no need for the researcher to make an instant decision about what is the next 'best question'. The strength of the open assessment task lies in the analysis of children's responses to the first, and only, question posed. This analysis preserves the richness and diversity of the data, rather than distilling it to simply a numerical form as in traditional assessment analyses.

Two major implementations of open assessment tasks have taken place in Australia; one study investigated aspects of science, a second looked at aspects of social education. In mathematics there have been several small-scale implementations; these were in number, measurement, space, and data. It is from the mathematics research that our examples are drawn. In this paper we shall look at the structure of open assessment tasks, the types of responses they elicit, and most importantly, the analysis of these responses.

Structure of open assessment tasks

An open assessment task requires the child to write, draw, or construct a response to a question; this is the strength of the open assessment task. With a permanent response, the interviewer–researcher is able to interpret responses and draw inferences uninterrupted by the need to find the 'next' question. The clinical interview requires a one–to–one arrangement; this is a strength of the clinical interview. On the other hand, the open assessment task is best suited to groups of children; this is a strength of the open assessment task.

An open assessment task requires that each child has a copy of the question or questions, and the means to record or construct their response; it also requires that the researcher is able to collect the children's responses (in some cases we have used photographs to record constructed responses).

The analysis of the children's responses is the critical step in open assessment task methodology. The analysis combines art and science; the art is in discerning a child's underlying conceptual meaning in their response, the science in the application of mathematical knowledge in classifying these meanings. The essence of the analysis is to focus upon the conceptual meaning that a response appears to represent. We say 'appears to represent' because it is our interpretation of the response that we are dealing with, not necessarily the child's 'reality'. This analysis, although not complex, is best explained through example; two examples are detailed below.

The children who provided the data

The children who provided the data came from a socio-economic cross-section of inner-city and suburban government and private schools. The schools used a wide variety of curriculum materials and resources and included many different teaching situations and styles, and as such were representative of schools across the nation. In each case approximately 200 8-year-old children attempted the task.

Example One: The Complete a Clock task

The first example described uses an unfinished clock–face. This task was based on an activity, described by Pengelly (1992), that was originally intended as a teaching activity. The activity was for use by junior primary children and was called 'Make a Clock'. The activity was adapted as a open assessment task for middle primary children and renamed 'Complete a Clock'. An advantage in using this task was that it was already known that it elicited a range of responses.

Curriculum basis for Example One

The national curriculum *Mathematics – a curriculum profile for Australian schools* (Curriculum Corporation, 1994) acknowledges that understanding the conventions of analogue clocks develops over time, implying that continuing assessment of these developing skills is important.

The task was developed to assess the curriculum outcome in the Measurement strand on Time for Level 2: "recognise key times on an analogue clock and tell the time of day on digital clocks in hours and minutes" (Curriculum Corporation 1994: p. 45). This outcome is one which is expected to be achieved by children who have completed their third year of schooling; that is they are usually about 7 years of age. By the end of Level 3 (the fifth year of schooling, when children are usually about 9 years of age) the curriculum outcome suggests that children should be able to "tell the time on digital and analogue clocks" (Curriculum Corporation 1994: p. 61); hence it is reasonable to assume that most 8 year-old children could show 9:30 on a drawing of an analogue clock. The task was presented as is shown in Figure 1.

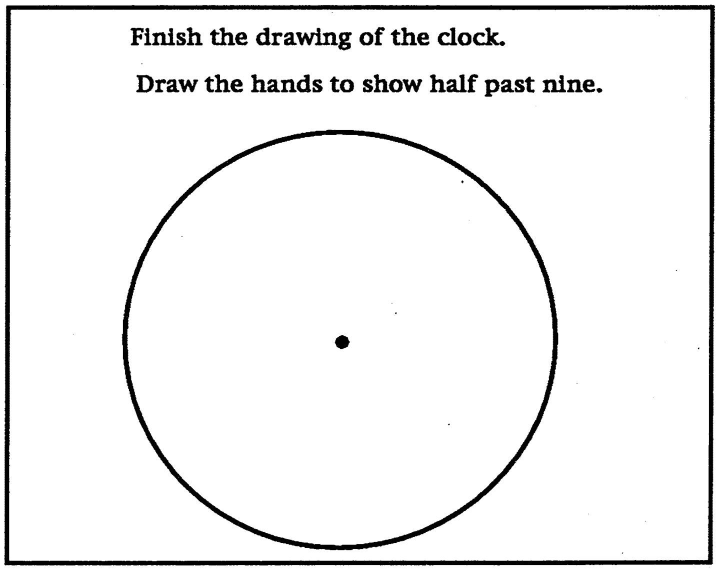


Figure 1: The Complete a Clock task.

Analysing responses to open assessment tasks

The examples described in this paper were designed to elicit a range of responses, with the intention of providing, as with any interview, opportunities to "see" children's understandings.

However the diversity of sights presented is at first bewildering! Some order needs to be imposed to enable sense to be made. The methodology used for responses to these examples is that first used for analysing conceptual understanding in science (Adams, Doig, and Rosier, 1992), and subsequently in mathematics (Doig, 1993a, 1993b) and in social education (Doig, Piper, Mellor, and Masters, 1994). The procedure described is extremely simple to understand. It should be noted, though, that for any set of data there is not, necessarily, a "correct" analysis.

The essence of the methodology is to read each child's response (whether text, diagram, or construction) with a view to understanding wholistically the ideas behind each response; a knowledge of the results of related research is important to this aspect of the methodology.

Next the responses are placed into categories wherein all the responses appear to have the same underlying idea; every time a response which suggests a substantially different idea from any before it is found, a new category of response is formed. Categories are thus mutually exclusive. Once all responses have been allocated to categories (that is, all necessary categories have been formed) short descriptions are written to identify categories for subsequent discussion, possible further analysis, and the drawing of inferences. Responses are then re-examined to make sure that the categorisation has been done consistently; if possible an independent judge is asked to use the category descriptions to sort the responses. Differences of opinion about categorisation provide the opportunity to clarify categories. The critical idea is that the categorisation should both preserve and clarify the differences in children's thinking revealed by the responses.

Analysis of responses for Example One

Table 1 sets out the categories constructed to organise the data from Example One. The categories are represented by the rows of the table. The columns are further sub–divisions of the rows designed to help us understand the diversity that exists even within the categories; for example, within the group of responses giving a correct clock–face, there are three possibilities. The same is true for other categories set out by row. Alternatively, if the focus desired is on 'correctness' then a column by column reading may be preferable; for example this approach shows that within the category of readable (that is, interpretable as 9:30) responses, there are at least four variations. The best option is to consider the table from both aspects; this gives the most complete understanding of the data. Examples of each category of response are given in Table 1, together with the percentage occurrence of each category of response.

Inferences from the analysis of Example One

The most obvious category to construct was that with correct responses. Nearly two–thirds of children could represent, acceptably, 9:30 on an analogue clock–face. However, a small number of responses (6) showed minute divisions on the clock-face. All of these displayed the correct time, but a number of these (4) were flawed because they had five marks between the numerals, thereby creating six intervals. These responses are examples of a misunderstanding of differences between continuous and discrete quantities; that is, a misunderstanding of the difference between the rôle of the space between marks, and the rôle of the marks themselves.

A further category of response was that of problems with the hands of the clock. The problems were of three types: there were those where insufficient hands were drawn; those where the hands were not differentiated; and those where the hands were reversed. The conventions associated with the hands of a clock are quite subtle. Some children appear to be unable to deal with this subtlety. Responses in this category would seem to indicate that these children are unaware that hands of different lengths refer to different scales. In some cases children do not appear to understand which hand refers to which scale.

Other responses were categorised as having problems with the numerals. When the numerals were incomplete or so incorrectly spaced around the circular region as to be visually at odds with conventional clocks, then the responses were categorised as having a problem with numerals. The fraction knowledge required to place twelve numerals equally around a circle is very sophisticated. Many children made good attempts at this aspect of the task, but it was clearly beyond their spatial and, or, fraction skills. Some responses had problems with both numerals and hands. These were combinations of the categories listed above. Despite the misunderstandings or lack of skill exhibited by these responses, some could be interpreted. They do reveal aspects of the child's understandings that need to be developed.

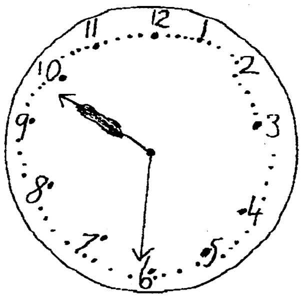
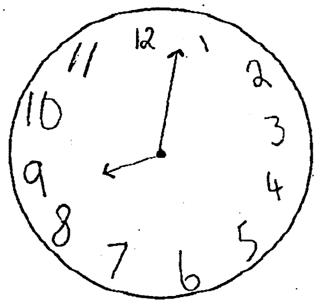
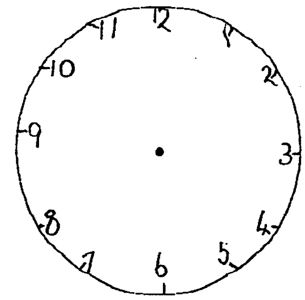
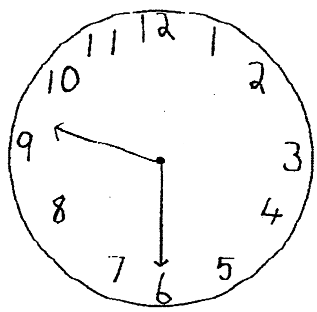
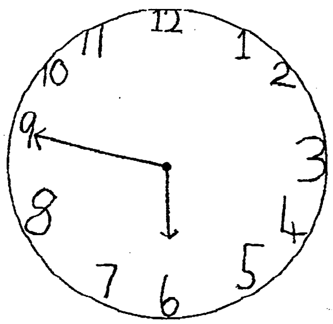
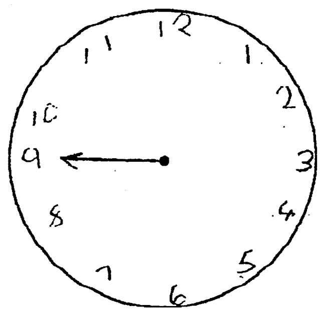
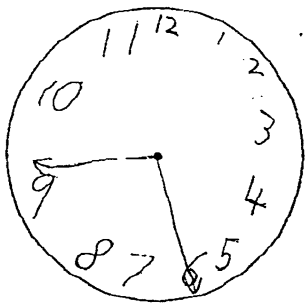
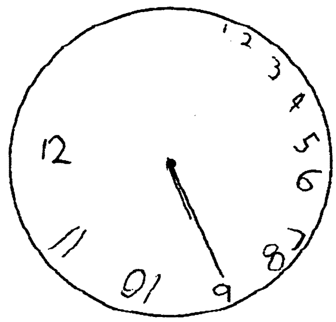
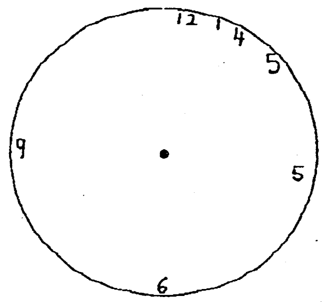
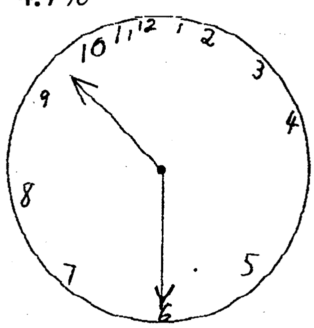
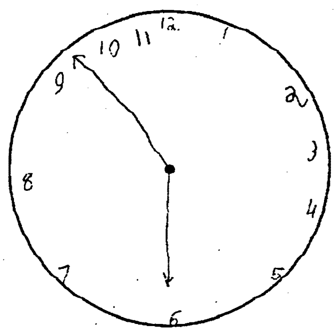
Category	Representations of time		
	Readable as 9:30	Unreadable as 9:30	Incomplete
Correct clock-face	60.8% 	3.2% 	0.5% 
Problems with clock hands	17% 	2.1% 	1.0% 
Problems with numerals	8% 	1.6% 	0.5% 
Hand and numeral problems	4.7% 	0.5% 	0%
Totals	90.5%	7.4%	2%

Table 1: Analysis of responses for Example One (n=189).

Example Two: The Make a Model House task

This task was based on the well-known problem that many people have in interpreting two-dimensional representations of three-dimensional objects and constructing the object. Mitchelmore (1976, cited in Eliot, 1987) in examining cross-cultural studies of spatial abilities found that cues for representing depth and perspective were poorly understood and difficult to understand. Children are being confronted with an increasing amount of two-dimensional material (printed and electronic), which they are expected to interpret, so this task was seen as adding extremely valuable information to teachers' portraits of children. The task used a 'plan' of a house that had a cube as its base and a triangular prism for its roof. The task required children to 'build the house' using match–sticks joined by plasticine (a type of modelling clay). The 'house' was the home of the Three Bears in the folk–tale 'Goldilocks and the Three Bears'.

Use the matchsticks and plasticine to make a model of the three bears' house.

Make your model just like the one in the drawing.

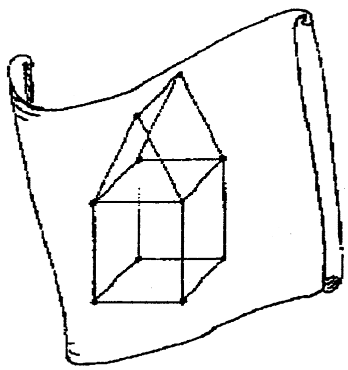


Figure 2: The Make a Model House task.

Curriculum basis for Example Two

This task was developed to assess the national curriculum *Mathematics – a curriculum profile for Australian schools* (Curriculum Corporation, 1994) sequence of outcomes in the Space strand. These outcomes were about using spatial ideas to interpret, draw and make. The profile suggests, that at Level 2 a child: "fulfils simple spatial criteria when making things from verbal and visual descriptions" (Curriculum Corporation, 1994: p. 38). This outcome is expected to be achieved by children who have completed their third year of schooling; that is they are usually about 7 years of age. By the end of Level 3 (the fifth year of schooling, when children are usually about 9 years of age) the curriculum profile suggests that children should be able to "pay[s] attention to the shape and placement of parts when matching, making and copying things, including matching nets with 3D shapes ... Make polyhedra in solid (with clay), hollow (with provided nets) and skeleton (with straws) forms." (Curriculum Corporation, 1994: p. 54). The task was presented as shown in Figure 2.

Analysis of responses for Example Two

Sometimes ordering the categories of response makes the methodology even more effective. That is, once the categories are 'settled' they are arranged in order, with the category containing responses showing the most sophisticated understanding first, then categories with responses considered to show less and less sophisticated understanding after. It is crucial for this ordering that the purpose of the task is clear and well-defined.

This ordering of categories is not necessary for all tasks; while it makes understanding responses easier in most cases, it is only strictly necessary if responses are being used for creating developmental continua (see Adams *et al.* (1992) for a description of developmental continua and their construction).

The ordering of response categories builds a picture of the diversity of responses, yet allows a sense of the increasing proficiency displayed by children to emerge. Table 2 sets out the categories constructed to organise the data from Example Two.

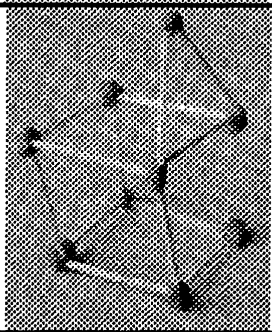
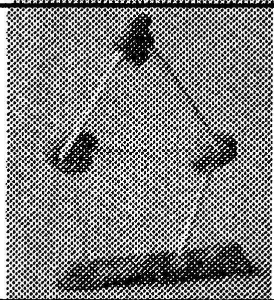
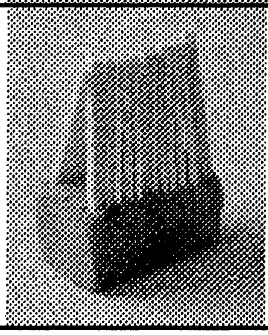
Category	Description of responses in this category	Percentage
Correct model	Correct 3-dimensional model of the house.	60%
3-dimensional model with subtlety problems		10%
Combination of dimensions		22%
2-dimensional interpretation		3%
Other responses		5%

Table 2: Analysis of responses for Example Two (n=227).

Inferences from the analysis of Example Two

Nearly two-thirds of children were able to construct the model from the plan correctly. This was very encouraging given that many children in the sample claimed never to have done this type of activity before (at least at school).

About ten per cent of the responses were substantially correct, but had minor deviations from the 'plan'. The responses indicate that these children can interpret this type of information and understand that it represents a three-dimensional object;

however some details are either ignored or over–looked. This may indicate either an immature appreciation of the conventions, or that the context (of a house) was so well–known that children were building more from memory than the plan.

Approximately a quarter of responses show that children interpret the 'plan' as a mixture of two– and three–dimensional elements. It may be that these children are viewing the 'plan' as representing a series of individual planes, rather than representing a solid. These responses could also indicate that at this age (8 years-old) children, with respect to understanding drawing conventions, are in transition from two– to three–dimensional representations.

A very small group of responses depicted the 'plan' as a two–dimensional object; there was no indication that the children saw the 'plan' as representing a three–dimensional object. A small number of these two–dimensional models were in reality 'drawings' of the plan, using matchsticks to represent the lines, and plasticine for the 'dots'. These were considered to be strictly two–dimensional.

Some responses did have the 'flat' house (two–dimensional) standing upright; these tended to consist of representations of a single face or wall. Whether these are truly two–dimensional is open to question. The children who made upright walls are certainly not adept with the conventions of representing solid objects in two–dimensions.

We would argue that their responses show that they are at least aware that three–dimensional objects can be represented by drawings. On the other hand those children who simply 'drew' the plan in matchsticks, knowing that it was a house–plan, knowing that they were to build a house, appear not to be aware of the most rudimentary aspects of this form of representation. In such a small sample (n=227) and with only 3 per cent of children's responses falling into this category, it would be rash to suggest more than this.

Whilst responses were categorised by the similarity of their spatial attributes, the final categories (if ordered by the sophistication of their understandings) bear remarkable resemblance to Mitchelmore's stages of development in three–dimensional representation (looking at three–dimensional objects and drawing them). In the case of this task, the process is the reverse (reading two–dimensional drawings and making three–dimensional objects), but the two schema appear to be isomorphic (Mitchelmore, 1980).

Discussion

The two examples discussed are meant to illustrate how open assessment tasks can reveal conceptual understanding and mathematical strategies on a par with clinical interviews. The form of analysis described preserves the richness of the data and makes coherent its apparent chaos. Further, during the process of analysis, the analyst is building theories about a child's (or groups of children's) mathematical understanding.

Commonalities revealed in children's responses, however, may or may not be developmental; it is not inherent in the data that more complex understandings naturally arise from more naïve understandings; what is revealed is simply the diversity of thought existing within the group being investigated. In some cases it may be legitimate to infer a developmental ordering of ideas; the researcher needs to be wary of succumbing to a 'stages' mentality. It is salutary to remember that the interpretation one categorisation provides is not the only one possible; another researcher may well provide a different interpretation. This being said, it is encouraging to note the consistency between the results depicted here and those of other researchers (see in particular Mitchelmore, 1980 and the 'Make a Model House' example).

As we have argued elsewhere (Cheeseman and Doig, 1995) educational tasks that reveal more of children's thinking than the common alternatives, are worth the extra time and effort needed to construct and analyse them. The richness of the data provided by such tasks, the wealth of detail revealed about children's thinking, is only one aspect of using open assessment tasks. A further practical application is gathering *a priori* information for planning effective learning programmes.

Both those engaged in research and those working within the classroom may find that open assessment tasks offer advantages over more traditional methods of exploring children's thinking. Where time, or the number of children involved prevents the use of clinical interviews and similar probes, open assessment tasks can uncover children's mathematical understandings.

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