COMPARING CURRICULAR APPROACHES FOR STATISTICS IN PRIMARY SCHOOL IN ENGLAND AND BRAZIL: A FOCUS ON GRAPHING

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Analysis of the curricula for primary schools in England and Brazil indicates that in both countries while there is emphasis given in policy documents to the importance of problem solving, the materials that are designed to support teachers' implementation of the curriculum in their classrooms reflects a more passive approach to the teaching of graphing. We draw on research evidence from studies with primary school children and with student teachers to argue for the importance of active use of graphing for the emergence of transparency (Meira, 1998). We discuss the implications for initial teacher education in order to support teachers whose own confidence and experience in statistics is very limited.

INTRODUCTION

We base this paper on an analysis of the curricula relating to statistics (data handling) for primary school pupils in England and in Brazil, focussing particularly on the use of graphs. Our analysis indicates that in both countries there is an attempt at the top level of curriculum design to emphasise problem solving and enquiry as the key ideas underlying the teaching of specific skills and ideas. However, these generalised aims present considerable challenges for primary teachers who may themselves have little background knowledge of statistical ideas, and who will therefore need to rely on more detailed support materials. In both national contexts we see that the interpretation of the curriculum objectives in such materials (textbooks, planning guides, exemplar activities and problems, assessment criteria) moves away from the more challenging notions of problem solving and enquiry to focus on progression in the difficulty of (drawing) graphs, and what has been called passive graphing (Pratt, 1995), in which producing, rather than interpreting or using the graph is seen as the purpose of the activity. Pratt (1995) and Ainley (2001) contrast this passive use of graphs with situations in which graphs are used actively as analytical tools in problem solving (see also Ainley, Nardi & Pratt, 2000).

We contrast this with the richness and complexity in the interpretation of graphs in non-pedagogic contexts revealed by Monteiro's research (2005) with student teachers in England and Brazil. Monteiro uses the term "critical sense" to encapsulate the perspective that these student teachers bring to interpreting media graphs, mobilising and balancing statistical skills with contextual knowledge and experience. We end with a discussion of the need for experiences in pre-service teacher education that can support the development of a view of graphing as an analytic tool and thus equip teachers to draw on their everyday experience of reading graphs to inform the design of classroom activities.

THE ENGLISH CURRICULUM

In England and Wales the National Curriculum sets out in broad terms what pupils should be taught, and, more significantly, the standards against which they will be assessed in national tests. The other countries of the UK (Scotland and Northern Ireland) have separate education systems. For simplicity 'England' is used throughout this paper to refer to England and Wales.

Further detail of the ways in which the curriculum should be implemented in schools is given within the Primary Framework, and this is the document to which most teachers turn first in planning their teaching. Handling Data is one of four strands within the National Curriculum for 7-11 year-olds, the others being Using and Applying Mathematics, Number and Shape, Space and Measures. The Primary Framework, (Department for Children Schools and Families (DCSF), 2006) however, divides the curriculum somewhat differently, with Handling Data as one of seven strands alongside Using and Applying Mathematics, Understanding Shape, Measures and three strands relating to aspect of Number. At another level of detail, Handling

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Data and Measures are grouped together for the purposes of planning blocks of teaching. In examining these different documents and levels of specificity we find rather different approaches to the teaching of statistics.

Within the National Curriculum, and within the key objectives of the Primary Framework, Handling Data is presented as a problem solving activity. The lead statement in the National Curriculum programme of study for 7-11 year-olds is “pupils should be taught to solve problems involving data”, with further statements specifying in more detail component skills and ideas such as “interpret tables, lists and charts used in everyday life”; “represent and interpret discrete data using graphs” (Qualifications and Curriculum Authority, 1999). In a similar vein, the objectives in the Primary Framework centre around the key ideas of ‘enquiry’ (a generic issue taken from Using and Applying which appears in every topic strand) and ‘answering questions’, with small but significant changes in wording signalling increasing complexity for different age groups:

- *Follow / suggest / plan and pursue* a line of enquiry by deciding what *information / strategy* is needed; *collect / organise and interpret* the information, / s*uggest extensions* / *review methods; identify and answer related questions.*
- Answer a question *by collecting / identifying,* organising and interpreting data; use graphs and tables to *represent / organise/ analyse and interpret* results and *identify further questions to ask.* (adapted from DCSF, 2006, our emphasis in italics)

However, looking at another level of detail reveals a slightly different picture. The criteria for assessment within the National Curriculum do not make explicit reference to problem solving, but focus on pupils’ ability to use tables and graphs to record, communicate and describe information. The kinds of graph to be used are specified (e.g., block graph, pictograms), but little reference is made to interpreting these. The emphasis on using statistical tools to solve problems has disappeared (QCA, 1999).

Similarly, whilst the Primary Framework appears to offer an excellent model of how progression can be developed in the learning and teaching of statistics around the theme of enquiry, what it presents are very broad objectives, which require a great deal of interpretation to translate into the design of classroom activity. More detailed guidance is offered in the form of plans for three two-week blocks of teaching in each school year. This is likely to be the level of detail that most teachers will attend to most closely. The tasks suggested are heavily based around questions which lend themselves to simple data collection, and presentation of categorical data using basic graphs (How do children travel to school? What are the most popular names in the school? What colour bikes do children ride?). Examples show different ways in which the data can be presented (tables, bar graphs, pictograms) but with little attempt to consider the strengths or weaknesses of different representations, the purposes for which the data might be used, or the possibilities offered by the use of technology. Although the language of enquiry is still present, the examples given still suggest passive graphing (Pratt, 1995), with little evidence of the use of graphs as analytic tools.

THE BRAZILIAN CURRICULUM

The National Curriculum Parameters (*PCNs - Parâmetros Curriculares Nacionais de 1ª a 4ª séries*) was published in 1997 by the Brazilian Ministry of Education (MEC). The PCNs do not have the status of a standard official curriculum for the First Years of Fundamental Teaching (compulsory schooling starting with 6 year old children). The states and municipality governments are responsible for the details and operational actions that make PCNs’ suggestions effective for local public school networks(1). The private schools have more independence to adapt their own programmes in order to achieve the PCNs’ prescriptions.

PCNs emphasise that the teaching of mathematics and statistics should be based on problem solving approaches that challenge pupils to elaborate different types of reasoning and processes using concepts and available technological tools. They also indicate three types of teaching content: conceptual, procedural and attitudinal contents (Brazil, 1997).

One of the innovations of the PCNs was to introduce data handling as one of four mathematics content blocks alongside other blocks that address number and operations; space and shapes; and measurement. At the time of PCNs' first publication, statistical notions were not taught in the First Years of Fundamental School. Therefore, the inclusion of data handling demanded important changes in teacher education programmes and textbook contents. Teachers needed to deal with a great challenge; teaching a topic they had never taught before or learned in their pre-service or in-service teacher education (Monteiro, Selva & Ferreira, 2000).

The PCNs suggest different contents for two teaching cycles in order to approach specificities of the ways in which school curricula are organised in different parts of the country[(2)]. The contents vary slightly considering that in the second cycle the objectives are wider than in the first cycle.

- (1st Cycle) Conceptual and procedural: Reading and interpretation of data presented in images; Collect data, and construct personal ways to organize and communicate collected data; Interpretation and elaboration of lists, tables and bar graphs.
  Attitudinal: Interest to know, interpret and produce messages that use graphical representations.
- (2nd Cycle) Conceptual and procedural: Collection, organization and description of data; Reading and interpretation of data presented in lists, tables, diagrams and graphs; Construction of graphs and tables based on data from media, scientific and other types of written texts, understanding the utilities of graphs as a global presentation of data and highlighting the relevant aspects.
  Attitudinal: Interest in analysing all meaningful elements of a graphical representation, avoiding partial and precipitated interpretations (adapted from Brazil, 1997).

The PCNs recommend that the teaching of graphing should be associated with other mathematical and statistical concepts and notions, other school subjects and pupils' daily lives. According to the PCNs, the main aim is to teach pupils beyond the level of knowing how to read and interpret graphical representations; therefore they need to be able to describe and interpret their real world experiences using statistical knowledge. Teachers should stimulate pupils to ask questions, make relationships, built justifications and develop an investigative spirit.

Although PCNs suggest that statistical knowledge is important for interpreting and critically evaluating data presented in daily life, there is not much discussion of how such knowledge should be developed. The document exemplifies topics of interest to children, such as: their birthdays, grandparents' nationalities, and football teams. However, it does not establish explicit connections between those examples and a problem solving perspective. In addition, the evaluation criteria presented on PCNs do not seem to approach the complexity of the aims that enable pupils to interpret data from graphs critically.

Since 1996, the MEC also periodically promotes pedagogical evaluations of a nation-wide range of mathematical textbooks. The results from the Fundamental School Initial Years textbook analyses were published in a guide (Brazil, 2006) that presents the principles and criteria for the evaluation and the reports of the approved textbooks. The guide helps teachers, schools and local state school networks to choose the textbooks that will be most suitable for their students.

In the latest review process (Brazil, 2006), 42 sets of mathematics textbooks were analysed (each one consisting of four textbooks), and 35 sets were approved. The analyses indicated that 82% of the approved collections included activities of reading and interpretation of data presented in tables and graphs. However, only 31% propose activities in which the students need to collect and organize data (Brazil, 2006). Most of the texts present only bar and sector graphs. There are few examples of line graphs. Inappropriate approaches that call bar graphs 'histograms' were frequently observed. Although the guide emphasises that in most of the collections, the activities with graphs are articulated with other curriculum areas, the analyses indicated that the content is not familiar to students from the Initial Years.

Despite the PCNs' references to the importance of statistical knowledge in allowing students as citizens to interpret graphs in their everyday life outside the school, there is no consideration of the differences between the construction and use of graphing knowledge in school and out-side-school contexts. For example, the use of media graphs in the teaching of graphing needs to consider the de-contextualization of the graph from the reading context as well its re-contextualization in school context (Monteiro, 2005).

LIMITATIONS OF THE IMPLEMENTED CURRICULA

It is widely recognised (e.g., Monteiro & Pinto, 2005) that there is a gap between curricula presented in policy documents and those actually presented in classrooms, as teachers interpret policy approaches through the lens of their own knowledge, experience and teaching styles. It is understandable that teachers who themselves have relatively little knowledge of statistics may rely heavily on materials such as textbooks or planning resources that will support this interpretation. In both the English and the Brazilian contexts, the ways in which graphing is presented in these materials tends to follow an epistemic fidelity approach (Meira, 1998) in progression. The relative transparency of a type of graph, that is, how easy it is to access the information it contains, is judged on the basis of inherent features, such as the scale, or the choice of blocks, bars, lines or crosses to represent data. The progression offered in the Primary Framework in England introduces block graphs for 5 to 7 year-olds and bar graphs for 8 year-olds. These continue to be used throughout the primary school in various forms, particularly as frequency graphs. Pictograms are introduced at about the same age, though with little consideration of why they might be useful. Line graphs and pie charts are introduced at ages 10 and 11 respectively, and scatter graphs do not appear at all within the primary school (DCSF, 2006).

This view of the progression in difficulty of graphs is closely tied to the relative difficulty of constructing them accurately with pencil and paper. Thus, the use of scales is a major marker of increased difficulty, and pie charts, which require knowledge of ratio and angles, appear only at the end of the sequence. However, there is research evidence suggesting that when the necessity to draw graphs by hand is removed, particularly in the context of computer-based graphs, children in the primary age range are able to work with line and scatter graphs well before ages at which they would meet them within the traditional progression (Ainley, 1995; Pratt, 1995).

Meira (1998) challenges the 'epistemic fidelity' view of transparency that focuses on intrinsic qualities of devices or displays and, in contrast, suggests that "the transparency of the device emerges anew in every specific context and is created during the activity through specific forms of using the device" (p. 138).

The emphasis in primary classrooms is often on the collection of data and the production of graphs, with the subsequent interpretation of the graph limited to relatively superficial reading of the data (Curcio, 1987). Pratt and Ainley (Pratt, 1995; Ainley, Nardi & Pratt, 2000; Ainley, 2001) refer to this kind of activity as passive graphing, and emphasise the potential role of technology in supporting the development of pedagogic approaches in which the graph is seen not only as an artefact but also as a tool in solving meaningful problems. Evidence from teaching experiments based on active graphing, which involves the iterative use of scatter graphs produced from data recorded in a spreadsheet, indicates the emergence of transparency as primary school children work on tasks where there are close links between data collection and the interpretations of graphs, within a meaningful problem-solving context (Ainley et al., 2000).

Children working on active graphing tasks are using graphs in ways that have similarities with adult uses of graphs in professional contexts. Gal (2002), discussing statistical literacy in adults, distinguishes these 'enquiry' contexts, in which data and graphs are used actively to achieve a solution, from 'reading' contexts where graphs are presented alongside other text and images, for example in advertising or journalism. However, we argue that even in the context of graphs used within the media, where the ability of the reader to read a range of often unusual graphs is seen as unproblematic, transparency is not inherent in the presentation of the graph but emerges as the reader engages with the context. When someone reads a graph, he/she can trigger knowledge and experiences from previous situations to be used in a current interpretation. This process of mobilisation does not happen automatically. Readers need to establish a certain level of engagement in the task to mobilise their previous knowledge and experiences to interpret a media graph. Therefore, there is no direct application of knowledge and experiences for the process of interpretation.

The processes and components related to this mobilisation seem to be complex, and a number of aspects need to be discussed. For example, media graphs are used in the discursive context that might emphasise or disguise aspects of the data (e.g. Meira, 1997). Therefore, readers of media graphs should not necessarily accept the ideas suggested by the data displayed. In this context, an ideal role of mobilisation should be to support critical evaluation of the data being interpreted. In order to reflect the complexity of the process of interpreting graphs, we develop the notion of 'critical sense' which is related to three dynamic processes: the mobilisation of knowledge and experiences; the emergence of meanings; and the balance of these elements involved in a context of interpretation for particular graphs (Monteiro, 2005).

CHALLENGING FOR CHANGE

From our analyses of aspects of the teaching of graphing in English and Brazilian curriculum documents, we identify some important elements. First, we draw attention to gaps between the prescriptive suggestion about graphing elaborated by curriculum makers and the classroom practices developed by teachers. The curriculum makers have suggested important factors that make considerable demands on teachers if they are to be effectively developed in classrooms. However, they do not seem to consider teachers' limited knowledge and experience of data handling. For example, both curricula suggest that data handling should be approached as a problem solving process and connected with pupils' daily contexts but do not give details about how teachers could achieve such challenging aims.

The national curricula analysed here do not appear to consider some aspects that have been discussed in research. For example, there is no clear recognition that statistics education is a specific area of knowledge. Presentation within the mathematics curriculum to some extent disguises the need for the particular aims and teaching approaches for statistics to be understood. There is also a need to challenge the linear logic about graphing that prescribes an order for working with graphs from the 'easiest' type (bar graphs) to the more 'difficult' types (e.g., pie charts, scatterplots), where difficulty is judged on the basis of the demands of constructing the graphs by hand. We argue that for graphs to become transparent, learners must have opportunities to use them as tools in solving problems. This might be achieved using an active graphing perspective that emphasises the learner's role as an interpreter and user of graphs, exploiting the support of technology, rather than focussing on the graphical representation itself. Such an approach can provide opportunities to learn how to be aware of the diversity of elements involved graphing contexts and to consider the development of critical sense that is necessary in balancing the different aspects involved.

We believe that the development of a wider curriculum perspective of graphing needs to be followed by improvements in the teaching approaches related to graphing in pre-service and in-service teacher education. In order to achieve this it is necessary that teacher education programmes encourage student teachers to reflect on their own interpretations of graphs and focus explicitly on the complex range of elements and processes involved.

We know that in Brazil several programs have developed some interesting but isolated experiences in supporting teachers to develop their knowledge about the teaching of graphing. It is necessary to promote networking projects that make successful pedagogical experiences, as well as difficulties to be considered, more widely available. In addition, the development of supportive workshops and research projects that make suggestions to improve the effectiveness of pedagogical initiatives on the teaching of graphing is fundamental.

NOTES

(1) Generally speaking, there are only two types of fundamental schools in Brazil: public non-fee-paying schools, which are supported by the government, and private fee-paying schools.

(2) In Brazil, schools have autonomy to organise the initial periods of Fundamental Teaching in cycles that do not have the length of a school calendar year.

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