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INVESTIGATING THE INTERPRETATION OF MEDIA GRAPHS AMONG STUDENT TEACHERS

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ABSTRACT. The official inclusion of the teaching of graphing in school curricula has motivated increasing research and innovative pedagogical strategies such as the use of media graphs in school contexts. However, only a few studies have investigated knowledge about graphing among those who will teach this curricular content. We discuss aspects of the interpretation of media graphs among primary school student teachers from Brazil and England. We focus on data which came from questionnaires and interviews which gives evidence of the mobilisation of several kinds of knowledge and experiences, in the interpretation of media statistical graphs. The discussion of results might contribute to an understanding of the complexity of the interpretation of such graphs, and to the development of pedagogical strategies which can help teachers think about the teaching and learning of statistics in ways that will support the balance of these kinds of knowledge.

KEYWORDS. : Interpretation of Graphs, Statistics Teacher Education, Statistics Media Graphs.

INTRODUCTION

The interpretation of statistical graphs might be considered as an activity which is related to a complex range of elements and processes. In current society, print media commonly use graphs to illustrate journalistic arguments in publications (e.g. newspapers, magazines, periodicals and public reports) that provide news and information for the general public. Media graphs are also increasingly used as resources to teach statistics at the school levels. However, the use of media graphs in *school* contexts demands reflection about the relationship between specific contexts of statistics graphs: reading (Gal, 2002) and *school* (Monteiro & Ainley, 2004).

In this paper we discuss data from research which set out to explore the activity of student teachers interpreting graphs taken from the media. The study was designed to identify and explore the elements and process which are involved in the interpretation of such statistical graphs. The aim of this study was to contribute to the discussion of teacher education situations

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in which student teachers can have opportunities to experience the complexity of the interpretation of graphs. These opportunities might support the development of approaches to the teaching of statistics which consider the different range of knowledge and experiences involved in the interpretation of graphs.

In the next sections we will present a research background from several studies in statistics and mathematics education which approached different aspects of the interpretation of graphs; and we will present our study and discuss contribution which it can make to the teacher education field.

INTERPRETATION OF GRAPHS AS A RESEARCH TOPIC

Several studies have investigated aspects of statistical literacy in the interpretation of graphs in school contexts. Curcio (1987) and her colleagues (e.g. Friel, Bright & Curcio, 1997) were concerned about the design of assessment tasks that can detect students' difficulties in comprehension skills using statistical graphs. Curcio (1987) assessed fourth and seventh grade students' interpretations of traditional "school" graphs. From the analyses of students' responses, three types of interpretations were identified: *reading the data, reading between the data*, and *reading beyond the data.* Although Curcio´s typology helps to understand the different types of approach to data displayed on graphs, the focus on traditional pedagogical tasks seems to restrict the range of situations to which the interpretation of graphs is connected.

Watson (1997) stated that statistical thinking needs to be assessed as it occurs in social settings outside the classroom. She suggested that unusual and misleading graphs, which occur in print media, might be excellent examples to motivate and challenge students. Watson proposed a three-tiered hierarchy model for assessing statistical literacy based on authentic extracts from the media. Teachers might use these tiers to appreciate the increasingly complex nature of progression in students' statistical thinking (Watson, 2000). Watson and Callingham (2003) have amplified the initial hierarchical schema, but continue to emphasise that the highest level of statistical thinking is associated with responses based on critical and questioning engagement with context.

Several authors have emphasised the importance of statistical teaching which considers the use of graphing knowledge in out-of-school situations (Meira, 1997; Ainley, 2000; Evans, 2000). However the activity of reading graphs might be different in specific contexts such as: *academic* (e.g. Wild & Pfaunkuch, 1999), *reading* (e.g. Gal, 2002) and *school* contexts (Monteiro & Ainley, 2004). Within *school* contexts the kinds of interpretation which pupils are asked to make are relatively limited, focusing largely on knowledge of statistical processes, with little attention given to the social context from which the data has (supposedly) been taken. Indeed, responses which do draw heavily on knowledge of the context are likely to be perceived as incorrect (Cooper & Dunne, 2000).

APPROACHING STUDENT TEACHERS´ INTERPRETATION OF GRAPHS

Several countries have included the teaching of interpretation of graphs as a curriculum topic in primary schools, e.g. England and Wales in National Curriculum (DES, 1989); and Brazil in Parâmetros Curriculares Nacionais (Brasil, 1997). Despite official inclusion, in some countries the teaching of graphing has been slow to develop (Shaughnessy, Garfield & Greer, 1996). The reality in most *school* contexts is still associated with conventional classroom settings in which the teaching of graphing emphasises several sub-skills by a succession of tasks, such as scaling, drawing axes and plotting points (Ainley, 2000).

One of the main approaches to changing this situation is to work with those who play a key role in statistics education: the teachers. Important initiatives have been developed in different countries in recent years. For example, Batanero, Godino and Roa (2004) discuss probability as a challenging topic to be approached in statistics teacher education. According to these authors, student teachers need to learn how to recognise the issues related to stochastic knowledge as well as develop didactical knowledge in order to facilitate the students learning processes.

However, the dynamism of school curricula involves more than rational knowledge related to statistics. Eichler (2006) emphasises that teachers´ beliefs represent important elements in understanding the way in which each teacher develops his/her statistics teaching. Therefore, the personal aspects which constitute statistics teachers´ practice influence their teaching approach, and continuing teacher education programs should have a crucial role in order to encourage and support innovations on their pedagogical and statistics knowledge (Paparistodemou, Portari & Pitta, 2006; Serradó, Azcárate & Cardeñoso, 2006).

In *school* contexts, teachers play a fundamental role in the construction of a teaching context for the interpretation of graphs which should be meaningful and purposeful for participants (Ainley, Pratt & Nardi, 2001). Teachers should legitimise students' directions of enquiry, redirect their attention, encourage certain initiatives and discourage others; provoke the negotiation of meaning, maintain proper articulation of activities and conceptual matters (diSessa, Hammer, Sherin & Kolpakowski, 1991; Ben-Zvi & Arcavi, 2001; Nemirovsky & Tierney, 2001; Lopes, 2006). Teachers need to guide the pedagogical setting towards situations in which statistically relevant aspects are discussed, such as posing questions related to the critical analysis of data or the necessity for the generation of new and useful information (Ainley, 2001; McClain & Cobb, 2001).

The utilisation of media graphs in a school context (Watson, 1997) seems to be an interesting innovation, as it brings together two different contexts of graphing (the *school* context and the *reading* context). Nevertheless, Adler (2000) emphasises that the utilization of resources from out-of-school practices produces an important challenge for teachers, because the

recontextualisation can be complicated and sometimes contradictory. That happens because school graphing activities are not simply a continuation of solving mathematical problems outside school (Evans & Rappaport, 1999; Adler, 2000; Ainley, 2000; Gal, 2002).

These demanding aspects of the teaching of interpretation of graphs are complex and they are not being taught during conventional pre-service teacher education (Cooney & Krainer, 1996; Monteiro & Pinto, 2005). For example, Monteiro, Selva and Ferreira (2000) investigated the interpretation of graphs among Brazilian primary school teachers. The data analyses revealed that some of participants did not know basic notions related to graphs. During the interview all teachers recognised the need to learn more about graphing. Most of them gave as a reason for this situation the absence of specific studies in this topic during pre-service or in-service teacher education programs. The data analyses revealed that the process of interpretation mobilised knowledge and feelings which play important roles in the understanding of the data. For example, one of the graphs was about the incidence of different types of cancer cases among men and women between 1990 and 2020. Another one was about the duration of mammal animal gestations. The authors observed that the personal involvement of participants with the cancer topic seemed to be an important 'mobiliser' of the contexts of interviews. For example, when they were interpreting the cancer graph the teachers carried out different strategies to try to understand the data such as measurement of bars and conjectures about the causes of the figure variations displayed. In contrast, most of participant teachers approached the graph about gestation of mammals by describing the data shown.

We believe that teacher education is a complex process that involves numerous specific variables (Monteiro & Pinto, 2005). It would be simplistic to make general statements which emphasise only one factor, such as the assertion that previous experiences which teachers had in a specific knowledge area might directly effect their teaching approaches in that particular area (Becker & Selter, 1996). However, we acknowledge that a pre-service course which provides a wider range of opportunities for learning different aspects of mathematical content might support better teaching approaches for primary school teachers. For example, we believe that teachers should have experience in situations in which they can become aware of the complexity of aspects involved in the interpretation of media graphs.

Pre-service student teachers are frequently seeking for practical answers, examples and strategies which they can use as teachers. In other words, they commonly believe that it is possible to learn all pedagogical skills during an undergraduate course. There would be a conflict (and in reality there is) when one later realises that there is no such possibility, in any educational field - to have straightforward and easy answers to the complexity of learning and teaching processes.

We agree in seeing as inappropriate the lecturers' attempts to approach student teachers' expectations by "answering" or "showing" how they can carry out their teaching practices. On

the other hand, a presentation of theoretical models without elements which might support an articulation of theory-practice is not an effective learning experience for student teachers. This would reinforce the dichotomy between theory and practice, leaving to students the task of building up their own pedagogical skills by putting together the fragmented pieces of knowledge we presented to them. This does not seem coherent with the goals of teaching/ learning as presented by new educational policies: we would be asking students to develop a different teaching attitude at school from our own practices as their lecturers, and therefore from their own experiences as students.

Our focus on media graphs also raises the issue of how people may act differently when reading graphs in different contexts. The activity involved when looking at a graph presented in a newspaper alongside accompanying text, or as part of an advertisement, may be quite different from the activity involved in using a graph in a professional context, and different still from the activity required in response to graphing tasks in a school context. In the part of the study reported here, carefully chosen media graphs were presented in a written questionnaire which was given to groups of student teachers. However, the questions which were asked about the graphs were designed to be more open than those which would normally be found in school contexts, trying to stimulate the kinds of concerns which might occur in a *reader* context. Whilst acknowledging the limitations of this approach in terms of accessing detailed information about the participants thinking, we chose to use this method in order to collect a sufficient body of data to test out some initial conjectures and to provide the basis for the design of a subsequent interview-based study.

QUESTIONNAIRE STUDY

The questionnaire study was carried out with British and Brazilian student teachers who were taking curriculum methods courses in primary school mathematics during the 2002/2003 academic year.

In total 218 took part, made up of Brazilian (100) and British (64) student teachers taking four year undergraduate education courses, and British PGCE (Postgraduate Certificate in Education) students (54) taking a one year course which gives *Qualified Teacher Status* (QTS).

The vast majority of the British student teachers (87%) and Brazilian (91%) were female. The British undergraduate groups were comprised of younger people than the British PGCE groups. For example, 78% of the undergraduate students were aged 19 and 20 years old while 61% of PGCE students were aged between 21 and 25 years old. The majority of Brazilian participants' groups (53%) were comprised of students aged 21 and 25 years old. Generally they were older than British undergraduate participants. For example, only 10% of the Brazilian participants were aged 19-20 years.

The British undergraduate students' groups were following specialisms in Mathematics, Science and English. The British PGCE students had range of academic backgrounds related to 25 different courses which were completed in at least 32 different universities in England and Wales.

At that time of data collection, unlike the British undergraduate participants the Brazilian student teachers did not follow school subject specialisms (Marcondes, 1999). In addition to the status of primary school teacher, the students could also take two different specialisms: educational supervision and school management. Therefore, they took different routes which allow them to be specialists in those two areas. For example, in order to be a school manager specialist they need to take the Statistics applied to Education course.

Most of the Brazilian participants were from working or lower middle social classes. A substantial number of these participants worked as well as studied. However, not all of them worked in the educational field.

The university where the Brazilian participants were taking the course demands higher scores from an exam which they took at the end of the secondary school than other universities. Therefore, the Brazilian participants' performance in secondary school is generally better than the regional average which puts them in a similar position to the British participants who were studying in a university with good reputation and high entry requirements.

We anticipated that the use of the same questionnaire tasks could allow a comparative analysis between the responses from the British and Brazilian. However, it was not intended to develop a comparison of the levels of performance among Brazilian and British participants.

In conventional use of quantitative methods the purpose of sampling is to use a relatively small number of respondents to find out about a larger specific group termed population (Gorard, 2003). However, in this study the groups of participants which completed the questionnaire were not chosen to be statistically representative of the population of student teachers in Britain or Brazil.

The questionnaire was given collectively to class groups with one researcher present at all data collection sessions. The first part of the questionnaire contained questions which asked about participants' personal details and their reading experiences. The rationale of these initial items was to have a general characterization of the participants (e.g. gender, age, subject specialism or degree), and to have information about reading situations in which the participants might have access to media graphs. The second section contained questions relating to the interpretation of media graphs. In this article, we discuss data from responses to items associated with two graphs which displayed data about road accidents (see Figure 1).

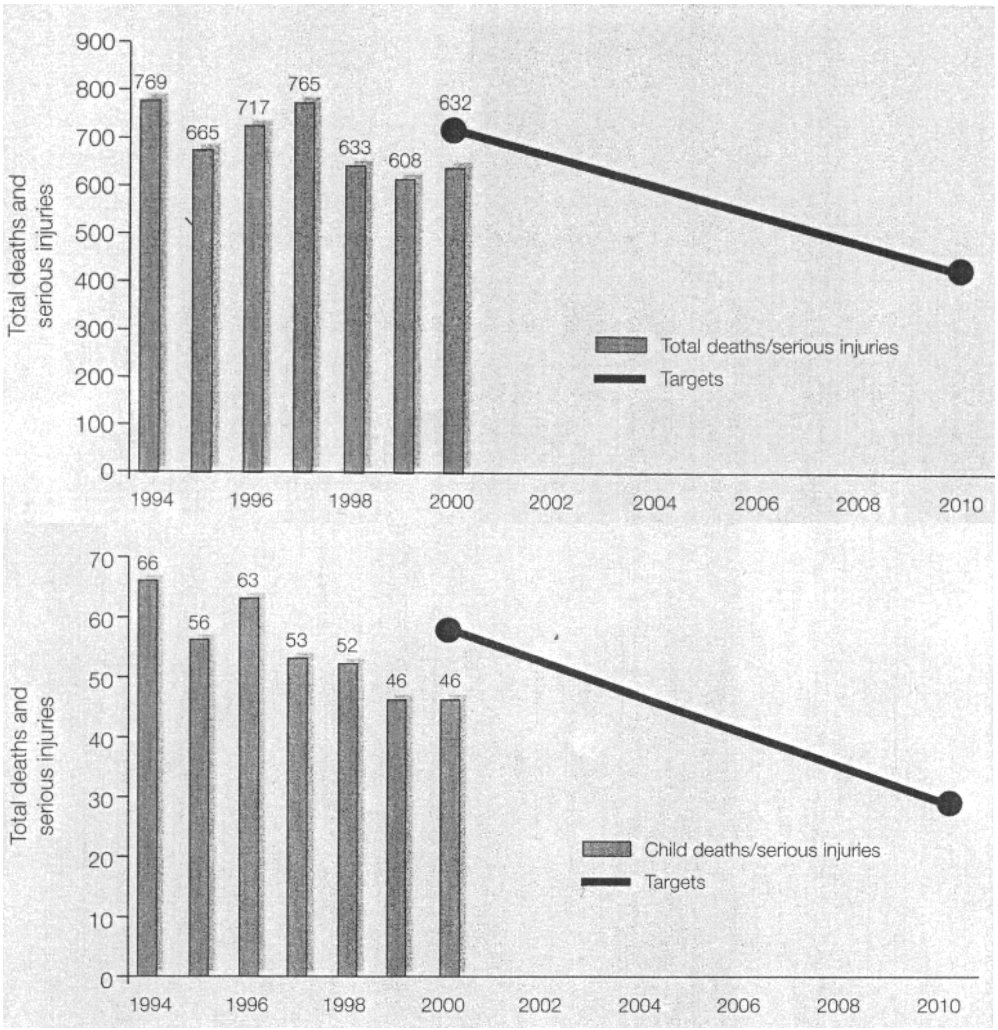

Figure 1. Road accident graphs task (Warwickshire County Council, 2001)

Question 1. If you could talk to the person that produced these graphs, are there any questions you would like to ask?

Question 2. If the information from these two graphs were combined what would the graph look like?

Question 3. Do you think that these targets are realistic?

Three main reasons influenced the choice of the media graphs used in the research tasks. Firstly, the graphs seemed to present accessible levels of statistical relationships. Basically, the graphs chosen were pictograms, bar charts and line graphs which present absolute, rational numbers, or percentages. Secondly, an attempt was made to choose media graphs which were related to familiar topics. Thirdly, we tried to select graphs which were free from technical errors or misleading elements. Therefore, unlike other authors (e.g. Watson, 1997) we did not want to emphasise the problematic aspects of the media graphs as a crucial element of the tasks. Figure 1 presents an example of these items related to graphs about road accidents. The questions posed about the graph were designed to give opportunities for participants to respond to the graphs in ways which might be similar to their responses when reading a newspaper or magazine.

The analysis of data from the questionnaires was assisted by the use of the NVivo software package. The analysis was based on counting of responses which depended of qualitative observation.

There were some differences in the patterns of reading activity reported by different groups. Among the Brazilian participants the most frequent type of reading was newspapers (43%), while among the British participants it was a variety of books which include fiction and non-fiction (46%), which is less likely to be associated with the inclusion of graphs. The majority of participants from all groups declared this type of books as their favourite type of reading.

Participants' responses related to the first item of the road accidents graphs task, which requested the formulation of questions about the graphs, were grouped into five categories: concerning the targets, complementary information, graphical representation, data collection and the purpose of the graph. Table 1 shows the numbers of responses in each category, and Figure 2 gives examples of the responses.

The majority of participants' questions requested additional information, including information about how the targets had been set, which could clarify their interpretation of the data (66%). A large number of those questions seemed to be related to the participants' concerns about the targets displayed (34%).

Table 1. Frequencies (and percentages) of responses according to the questions raised and group

	Group			
Type of questions raised	British Undergraduates	PGCE	Brazilian	Total
concerning the targets	49 (33)	40 (33)	54 (35)	143 (34)
Requesting complementary data	43 (29)	37 (31)	54 (35)	134 (32)
Questioning graphical representation	27 (18)	22 (18)	17 (11)	66 (16)
Questioning data collection	9 (6)	15 (12)	15 (9)	39 (9)
Questioning purpose of the graph	19 (13)	7 (6)	10 (6)	36 (8)
"I have no questions"			6 (4)	6 (1)
Total	147	121	156	424

Concerning the targets

- How/why did you set the targets observed? (*British PGC*E)

Requesting complementary data

- How many were deaths and how many were serious injuries? (*British undergraduate*)
- Were there any particular contributing factors to the increase in road deaths in 1997 such as particularly bad weather? (*British PGCE*)
- What are the geographical characteristics of Warwick region? (Brazilian)

Questioning graphical representation

- Why is the target line drawn higher than actual death/injury number for 2000? (*PGCE*)

Questioning purpose of a category of the graph

- What do you classify as a serious injury? (*British PGCE*)

Questioning the data collection

- How did you produce those numbers? (Brazilian)

Figure 2. Examples of main aspect of the questions raised about the road accident graphs

Generally speaking, the most frequent categories of questions related to participants' concerns about technical aspects of the data collection, as well as possible variables which might affect the data displayed. On the other hand, there was a lower frequency of questions which only focused on graphical representation itself. This was an indication that most of the participants' interpretations were not restricted to the data displayed on the graph, but that they might be mobilising other previous knowledge and experiences about the topic of road safety.

The second item of the road accident graph task asked about the shape of a hypothetical graph which would combine the data from both road accidents graphs (see Figure 1). The participants were asked to make a sketch of the graph rather than producing an accurate drawing. The rationale for this item was to provide another type of opportunity for the participants to approach the data from both graphs in more detail rather than to evaluate their skills in constructing a graph. The responses to this item indicated that most participants understood the specific statistical relationships in the graphs. A small percentage of participants (8%) indicated some misconceptions about the graphical representation. This suggests that technical reading of the graphs was not problematic for the majority of the participants.

The third item relating to these graphs asked about whether the targets which had been set for the reduction in accidents were realistic. The frequencies of responses to this item suggested that a substantial number of participants saw the targets displayed as problematic. For example, a substantial number of participants (41%) responded that the targets displayed on the graphs were not realistic, and another large group (34%) answered that they were uncertain. A small percentage of participants answered that the targets were realistic (13%). This suggests that the majority of the participants were taking a sceptical approach to the graph and not simply accepting the data for the targets at face value. Participants' responses for item 3 were also analysed in terms of justifications given for their answers (see examples in Table 2 and Figure 3).

Table 2. Frequencies (and percentages) of responses according rationale and group

Rationale for the answer	Group			Total
	British Undergraduates	PGCE Students.	Brazilian Undergraduates	
Based on opinion	20 (31)	21 (39)	59 (59)	100 (46)
Based on the graphs	23 (36)	19 (35)	26 (26)	68 (31)
Both graph- opinion	17 (27)	08 (15)	06 (6)	31 (14)
Did not answer	04 (6)	06 (11)	09 (9)	19 (9)
Total	64	54	100	218

For this item there was a noticeable difference between the responses given by Brazilian and British participants. A high proportion of British participants' responses included consideration of some aspect of the graphs (63% of PGCE and 50% of undergraduates). On the other hand, the majority of the Brazilians based their answer more on personal opinion about the data (59%). We conjecture that this difference in the pattern of responses might be related to the participants' background. For example, among the Brazilians participants there was higher percentage of frequent readers of print media which publish graphs. In such media publications, graphs are typically set alongside text which relates to the same context, but they are rarely referred to directly within this text. Indeed, their function often seems to be primarily to enhance the visual appeal of the presentation, rather than to add significantly to the discussion and analysis of issues. Thus, the fact that a larger proportion of Brazilians responded to this item only on the basis of their opinion could be associated with their familiarity with reading *contexts*, where readers do not generally make a technical analysis of graphs.

Based on opinion

- Yes, because drivers will be more informed from campaigns to decrease road accidents. (*Brazilian*)

Based on the graphs

- They would appear so, as there is a general downward trend in both graphs and they are already below the present target. (*British PGCE*)

Both graph – opinion

- Yes, they are the same as the gradient between 1994 figures and 2000. No, it is unlikely that road accidents could ever be as low as in 2010 unless people change the way they drive and don't walk onto roads. (*British undergraduate*)

Figure 3. Examples of main aspect on which the answer about targets was based

Similarly, we see that the British participants tended to make more use of justifications relating to the graphs only, or to the graphs in combination with opinion. The use of media graphs (or at least of graphs similar to those in the media) is not unusual in *school* contexts in Britain, although the tasks within which they are used tend to focus on practicing skills in reading specific information from the graph, rather than on interpretation. We might therefore conjecture

that British participants were more likely to construe the questionnaire task as a *school* context.

However, for us a more interesting result is that references to personal perspectives and opinions based on knowledge of the context were involved in the majority of the participants' justifications (60% of responses in total based on opinion, or on both opinion and graph). This provides strong evidence that participants were drawing on their experience and knowledge of the context of the data, rather than relying entirely on a technical reading of the graphs. Whilst this might be the response that would be expected from adults encountering such a graph in an everyday context, this is not the way in which graphs are generally to be interpreted within school contexts. This reinforces our sense of the gap between school and out-of-school contexts for interpreting graphs.

INTERVIEW STUDY

The use of interviews was not a form of mutual confirmation or a validation of the data collected from the questionnaire. Instead, it was our intention to have two complementary datasets (Gorard & Taylor, 2004). The use of interviews for new data collection was aimed at obtaining more detailed elements from the participant's interpretations.

The 118 British students and the 100 Brazilian participants who responded to the questionnaires were asked if they would take part in a further stage of the research. The vast majority of students who gave a contact gave an email address, which enabled us to contact a number of British volunteers to participate on the interview stage. In total 13 British participants were interviewed six months after they completed the questionnaire. We also considered conducting interviews with the Brazilian participants. However, this became unviable for a number of practical reasons.

The interviews were conducted in a quiet and well illuminated room at a university building which was reserved for that purpose. Each student was interviewed individually. The material was displayed on a desk and the student was seated in a position which allowed her/him to participate in the interview comfortably.

The copies of the graphs were presented in plastic folders. Each question was asked orally as well being shown printed on a sheet. This procedure allowed the participant to reread the question if they wanted to do this.

The timing of the interviews varied according to the availability of the participants. Generally, the interviews happened between 10 a.m. and 2 p.m. The Interviews lasted between 30-60 minutes. With the permission of the participants each interview was audio recorded and videotaped. The video camera was placed on a tripod which was situated beside the desk. The mini-disk recorder and a microphone were placed on the table. Despite the visibility of the recording apparatus the participants did not seem intimidated by the equipment.

The audio and video recording provided more accurate data for analyses, such as aspects of body language and intonation of participants' speech. The use of digital devices also facilitated the transcription of the interviews and analyses of the videotaped situations because audio and video files could be easily manipulated.

The interview study included the same graphs given on the questionnaires (see Figure 1), and served to investigate the typology of Curcio (1987), who proposed a multiple choice test composed of three kinds of questions for students interpreting traditional school graphs: reading the data, reading between the data, and reading beyond the data. In our study, the utilisation of Curcio's typology was not a kind of "replication". The context of the interview, the graph topic chosen, and the formulation of questions (see below) seemed to propose a different approach for the process of interpretation.

- *Reading the data* questions: What is the total of number of deaths and serious injury per year? What is the lowest actual death and serious injury rate?
- *Reading between the data* questions: Between 1994-1995, and 1997-1998, there was a decline in the number of deaths and serious injuries. Which period represents the greatest decline? Which years represent the highest and lowest number of deaths and serious injuries?
- *Reading beyond the data* questions: What is your prediction for death rate and serious injury in 2001? If the targets for 2000-2010 were met, what do you think the pattern might be for 2010-2020?

The interviews were also learning opportunities for student teachers to think about their own interpretation of graphs. They could also reanalyse their previous questionnaire answers, and discuss their expectations about teaching graphing. Generally, the questions involving "reading the data" and "reading between the data" demanded direct answers. However, these questions provided an opportunity for the participants to carry out an initial exploration of the data. On the other hand the "read beyond the data" questions generated a wider and deeper exploration of data displayed on the graph.

In order to analyse the interviews we used a microanalysis approach based on suggestions from Strauss and Corbin (1998). This approach began with a scanning of the whole transcription of each interview. A further stage of analysis was the production of comments on the scanning of each protocol.

After this process of scanning and commenting on the interviews as whole, sections from several interviews were selected which seemed particularly interesting to discuss the elements and processes related to interpretation of the graphs. We developed a line-by-line analysis of these sections with the rationale of identifying in more detail the elements and processes involved.

We present some examples of interpretations produced when we asked the "read beyond the data" questions, which might help our discussion.

The first exchange comes from the interview with Betty, a 41 year-old PGCE student with a degree in English. She was trying to identify any trend related to the increases and decreases during the period between 1994 and 2000 to answer the question.

> R : "What is your prediction for death rate and serious injury in 2001?"
>
> B: "In 2001… Well I don't know. It's… *there doesn't seem to be a trend*. It's gone from 765 to 633… it's dropped down again, but then it's gone up to 632 [year 2000], and here I'm presuming that this was the rate it wasn't the set target. *I'm presuming but either way even if you look at the graph, it has gone up*".

Betty was looking carefully at the figures presented, and realised that the graph presents the 2000 rate as the starting point for the target. She seemed concerned about the graph's structure, which is clearly associated with cognitive aspects. In the next part of the interview she continued describing technical aspects involved in the graph, but she interpreted the graph based on her personal experience.

> B: "But throughout the whole period there hasn't been a set trend it dropped down [1994-1995], it's gone up [1995-1996], it's gone up [1996-1997], dropped down [1997-1998], dropped down [1998-1999], it's gone up [1999-2000]. If you based it on that… My husband is a currency trader; so all day is very boring he looks at graphs all day. And he follows trends. That's how he buys and sells currency depending on trends. So, he would look at this graph, he would say "are well the trend on it is to fluctuate" and he would draw lines in, and then he would say: "ok, dropped down, went up twice, dropped down twice, it's gone up". Now he would plot a line to see, and he would go back over many years, he would look for the trend to see it follow a certain pattern. It is actually quite interesting. So he would want to look at more than this, he would probably say: "well maybe it would rise a little bit". But, again for me I don't have any information. I don't know what they're doing. Are they… you know… advertising more, trying to educate people, making people to wear seat belts, and things. It's hard to predict from these figures what's going to happen".

The confrontation between the description of currency trader's strategies of analysis and the engaged context of interpretation seemed to be a justification for the limits of an efficient application of technical procedures. Then, she started to conjecture about the social context to which the data might be related. When encouraged to specify a prediction, she recognized that it was difficult but she make one.

> B: "If I have to then, I would say it would rise slightly. Well if was 632 in 2000, maybe in 2001, if it rose there, maybe 640, something like that. But it's a guess. And I don't have enough information to be able to make a trending (moving with her hand like a curves of a graph, going up and down)… a trending estimate of it".

It seems that her reasonable answer was based on the articulation of cognitive, affective and contextual aspects about data presented on the graph.

In the interview with Teresa, a 19 year-old second-year student taking Maths specialism, we can also observe similar arrangement of the aspects involved in the interpretation. Facing a question that did not have "exact answer", she initially tried to observe any tendency from the data displayed. Suddenly she realised that possible tendency could not be the only factor that can predict the answer. Then, she tried to make suppositions based on her opinion about the possibilities of change in the data.

R : "What's your prediction for death rate and serious injury in 2001?"

T: "Hum… Well… From this it looked like it kind of … went down and then went up, went down and then starting to go up… So it might got a little bit more… But than it depends on a kind of what's being changed. Maybe… Like whether they've done anything in particular to try and reduce road accidents so they just make a prediction… I don't know… Yes, say… say 665. I mean that will be … that kind of match the graph slightly… so we're going to go lots a little bit like this"…

After she gave the answer considering the social factors, she "came back" to the graph to justify that her interpretation would be coherent with the trend presented. However, in the following part of the interview, she demonstrated her discomfort with the representation of the target.

T: "The target… I don't know. The targets don't really mean anything; I mean you can put the target to go down to zero… So if it is about there…then that is about 665 if the targets right. I mean they've gone up a bit from here, haven't they? [Year 2000] Perhaps, they will stay the same. (…) I don't know. I mean I wouldn't… It's difficult, because always you are a bit suspicious about where it came from…then You know perhaps all the speed limits have been changed now in 2000 and what … certainly brought all the speed limits down, put road humps and things in all dangerous the roads and… So… Yeah".

The same kind of sceptical approach was observed when she was answering the next "read beyond the data" question. She made a distinction between what the graph represented, and what would be a "realistic" answer based on her own analysis of the data.

R: "How about if the targets… from 2000 to 2010 were met. What do you think the pattern might be from 2010 for 2020?"

T: "If they were met! Wow! That will be good. From 2010 to 2020… I think it will probably level out… hum… because always is going to be some… It might be down a little bit more… But… (Measuring with fingers on the graph). It is not going be down the same steepness as because we will never get nobody dieing unfortunately. So I think it will go down perhaps a little bit and level out. I think. Yeah".

R : "Do you guess a number?"

T: "By 2020, perhaps… I don't know… Perhaps 300 even, maybe, yeah".

R : "Do you want to comment on this…?"

T: "Hum… I mean… Yeah… Deaths and serious injuries… there was a serious injury… and you can always classify a serious injury as the same every time? Yeah… and… I suppose Warwickshire does that mean all of roads in Warwickshire? Are all the motorways included or… that kind of thing? The target I don't really… I mean… They… It looks like they are taking a line… near perhaps I don't know… But I don't think it sounds realistic… and then… Well, I suppose unless they… If they had a bit writing to say what, and how they're going to make this happen. There, its not going to happen by magic, is it? So, yeah… (…) This is always interesting in the way… I know you can't really compare them. But they're put next to each other on a kind of "compare these" kind of way. But, you can't really compare them because it's… I don't know whether the proportion is going down or not… Don't know".

Teresa definitely did not believe in the trend represented on the graph, and analysed the structure of the graph criticising the implicit intention of showing the relationship between actual rates and targets displayed as rectilinear decrease.

The following exchange is from the interview with Hillary, a 35 year-old PGCE student with degree in Music. She seemed to want to believe in the trend, but it also seems that she did not find a strong argument to base her answer on.

R : "If the target for 2000-2010"… there is a target there… "What do you think the pattern would be from 2010 for 2020?"

H: "20… All right… hum… I think provided that technology doesn't take over people's well being… Then… I think the pattern should decline. But there are so many other things that might influence that pattern, like population rates … and… It is difficult to say… it is really difficult… it is hard question that… But I think… I think it would be a decline. I think there will always be a decline, because it is such important issue… And then… There obviously… it always has been history of some kind of decline. But obviously things come along the way that interrupt the flow… obviously here (pointing to 1997 figure on the graph) there is… more deaths on the roads. There are reasons… Well, I don't know. It is hard to say whether it's death and injuries. (…) But obviously that was addressed, because there was a big drop there (1997-98). So, I think there's always a kind of picture of a decline, or an attempt for a decline. With something as serious you know… as this issue".

Hillary alternates between looking at the patterns shown on the graph, considering the context in which road accidents occurs, and expressing her desire to see safer roads with lower levels of accidents. She seems to be reluctant to face up to the complexity of the question. However, when she was encouraged to try to specify a prediction, Hillary managed to "guess" an answer that seems to be based on the graph, but considering aspects such as the "hope" that was implicitly present on the interpretation.

R : "If could say a rate as well?"

H: "Rate? … Do you want that I say what I think that death and injury rate might be…? Right. So if it's starting at 500 which is obviously that's what they're hoping… I don't think it's actually going to hit the bottom. I think there is always going to be deaths and serious injury on the road. I don't think you ever avoid that happening, but it might be… For instance, a target… realistic might be straight from 500 to… say 300… Yeah, it seems a realistic target".

After Hillary answered the questions, the interviewer invited her to reanalyse the answers produced months before. It was an opportunity for her to compare both situations of reading the graph. But it was a chance for her to make explicit a factor which might be meaningful for her interpretation: she was actually involved in an accident.

H: "I have been involved in an accident myself … It wasn't a particular serious accident. But, …I can perhaps relate to these statistics more …I think. I can actually see what it's telling me".

We can infer from analyses that Hillary's motivations and wishes played a prominent role in her interpretation. The fact that she cares about the road accidents, and that she was actually involved in one of them, was an essential meaning of the graph for Hillary. For example, she was trying to see what she wished to see, even though criticising and recognising the limits of her interpretation.

DISCUSSION

It was never our intention in this study to make direct comparisons between the responses of the different groups of students involved, although we conjectured that age and life experience, or subject background, might be factors which would affect students' responses. Differences in the school curriculum between the UK and Brazil (where statistics is a relatively new topic) also suggested that there might be discernable differences in responses. However,

despite their different backgrounds, we did not find great differences between the performances of the groups of participants, and the similarities in the ways in which responses mobilised different kinds of knowledge were more striking.

The responses to items 1 and 3 of the road accidents graphs tasks (see Figure 1) suggested that in making their interpretations participants amalgamated their statistical knowledge with other elements related to their knowledge and personal experience about the context which in which the data was set. Furthermore, the majority of participants displayed an ability to think critically about aspects of the data presented in the graphs, and to justify their ideas by drawing on statistical and/or other sources of knowledge.

The nature of the tasks used in the questionnaire constitutes an important aspect of our analysis. Because of their origins, the graphs were associated with *reading* contexts. In these contexts people can develop interpretations of graphs which do not necessarily focus on statistical and technical analysis of the graphical representation, but may be of a more impressionistic nature, based on the immediate visual impact and on expectations about the source of the data. However, to compose the questionnaire tasks, the graphs were extracted from the original sources, as generally happens when media graphs are transferred into *school* contexts, with the result that more emphasis may be placed on the graph itself. As in other *school* contexts of interpretation, the questionnaire emphasised written responses, limited the time available and restricted the way in which the participants could express their interpretation of the graphs. On the other hand, the questionnaires tasks also differed from conventional *school* contexts because the items tried explicitly to develop a questioning attitude from the readers. For example, the items asked the participants to produce questions and express their views, rather than just answering questions.

Our analyses of interviews suggested that the way in which we asked about predictions from the data helped the students in building interpretations that involved aspects which were objectively absent. It seemed that as they worked through the interview the graph became more transparent: they looked at the graph, but they also looked through the graph to consider the real-life context. They seemed to be aware that technical knowledge about the interpretation was not enough to answer the questions. They needed to use other resources such as opinions and feelings about the data, and knowledge of the context. The participants could travel through symbolic space (Carraher, Schliemann & Nemirovsky, 1995), which emerged from the interpretation. However, on the other hand, they recognised that they needed to balance the different elements which played roles in their interpretation.

The part of our study reported here supported the idea of *critical sense* which has been elaborated by Monteiro (2005) to encapsulate the way in which a sophisticated reading of graphs involves mobilising a range of different kinds of knowledge and experience. For example, our analyses suggest that readers may make references which connect the quantitative relationships

displayed on the graph with their previous knowledge about the processes of data collection and analysis, and with knowledge of social context from which the data has been drawn, or may respond on the basis of personal experience or opinion with little reference to the data. We argue that a complete reading of a graph involves *balancing* these different elements appropriately.

Thus we see critical sense as offering a different perspective on the statistical literacy needed for the interpretation of media graphs from that presented by Curcio (1987), whose category of 'reading beyond the data' seems to focus essentially on cognitive skills. Our concern with the teaching and learning of graphing leads us to question whether traditional pedagogic contexts offer opportunities for student teachers to engage in the kind of activity in which they consider the complexity of elements and processes involved in the interpretation of graphs.

Consideration of the features of *reading* contexts, *school* contexts and the hybrid nature of the questionnaires and interviews tasks has helped to highlight evidence of the complex relationship between elements of interpretation of graphs which are related to both school and out-of-school kinds of knowledge. This in turn raises pedagogical implications for the teaching of graphing. We suggest that the teaching of graphing should be based on opportunities to learn how to be aware of, and to balance, the diversity of elements involved in the interpretation of graphs. 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. Through such activity they may become aware that the isolation of statistical knowledge from other types of knowledge and experiences can be difficult and ineffective.

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