

# CRITICAL SENSE IN INTERPRETATIONS OF MEDIA GRAPHS<sup>1</sup>

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*This paper reports on a study that investigated the interpretation of media graphs developed by student teachers. The analyses of interviews indicate that cognitive, affective and contextual, aspects might constitute important components of the interpretation of graph such as those that we can find in print media. Particularly we discuss Critical Sense in graphing which is a skill that people can use to read the data, building an interpretation that balances these different aspects. The discussion of results might contribute to an understanding of these aspects, and the development of strategies, which help teachers think about the teaching and learning of graphing in ways that will support the development of Critical Sense.*

## INTRODUCTION

The interpretation of graphs might be conceptualised as a process by which people can establish relationships within data and infer information when reading graphs. In this paper, we discuss the idea of Critical Sense in graphing as a skill to analyse data and its interrelations rather than simply accepting the initial impression given by the graph (Monteiro and Ainley, 2003).

The term ‘critical’ identifies an important philosophical aspect, which is related to social, political, economical and affective issues involved in the educational process (e.g. Freire, 1972, 2003). Researchers have also related this critical perspective to mathematical education (e.g. Skovsmose, 1994). Our approach converges on general ideas developed in those studies. However, we are especially interested in the study of Critical Sense in graphing as an important skill related to the role of citizens, who need to be able to look critically at statistics presented by different sources.

In particular, Ainley (2000) states that the increasingly widespread use of graphs of many kinds in advertising and the news media for communication seems to be based on an assumption that graphs are transparent in communicating their meanings. The transparency is conceptualised as being inherent in the graph itself. In contrast to this perspective, Ainley (2000) argues that a graph may be considered as transparent for a particular user if it is both visible to reading, and invisible in giving access to features of the phenomenon it represents.

Ainley (2000) emphasises that the transparency of graphs emerges from the process of using them in a specific context. For example, when readers engage in a meaningful situation of interpretation they can use graphs to imagine ways of travelling through a symbolic space where events and narratives unfold (Carragher, Schliemann, and Nemirovsky, 1995).

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We believe that the interpretation of graphs is a complex process in which different elements are involved. In particular, we suggest three aspects, which are related to the idea of Critical Sense: cognitive, affective, and contextual. Certainly, this classification does not cover the entire range of components, but it seems helpful in our investigation of the problem.

Critical Sense in graphing is linked with the cognitive processes, which are associated with “formal” knowledge, such as that linked with the structure of graphs: framework, specifiers, labels and background (Friel, Curcio, and Bright, 2001). The cognitive factor might also be associated with the critical role of citizens when reading graphical representations. We need to be aware of and criticise graphs that might contain technical errors in their presentation, or may be technically correct but display irrelevant or misleading content.

To be critical is not just an intellectual or rational action, but also has an affective component. Even though professionals with high levels of schooling, and technical knowledge in graphing, utilise aspects from their beliefs and desires, when they are interpreting graphs such as those which we can find in print media (Monteiro, 2002).

The graph is not itself an isolated or neutral construct, it displays a content which might be related to a wider range of topics. The term context might be related to that content but also it might be associated with the situation in which the interpretation of graphs is developed. Gal (2002) suggests two main kinds of contexts: ‘enquiry’ and ‘reader’. In *enquiry* contexts people act as ‘data producers’ and usually have to interpret their own data and report their findings (e.g. researchers and statisticians). *Reader* contexts emerge in everyday situations in which people see and interpret graphs (e.g. graphs are published in different types of periodicals). *Reader* contexts demand a certain level of *statistical literacy* in which readers can interpret, critically evaluate, and comment on statistical information, arguments, and messages.

Cognitive, affective, and contextual aspects are interrelated during the interpretation of graphs. For example, cognitive aspects should also encompass informal knowledge, such as that related to intuitions, which might be associated with beliefs and other kind of affective elements. Therefore, we can use the notion of *inclusive separation* (Da Rocha Falcão et al., 2003) to remark the fragile borders between these aspects.

We see Critical Sense in graphing as a skill in which people balance the influence between these three elements. The teaching and learning of graphing in ways which encourage the development of Critical Sense is a challenge for teachers who need to guide the pedagogical setting to situations in which statistically relevant aspects are discussed (Monteiro and Ainley, 2003). In the next sections we discuss part of a study which explores Critical Sense in graphing in student teachers, as a way of helping us, and them, think about teaching and learning graphing in ways that will support the development of Critical Sense.

## EXPLORING CRITICAL SENSE IN GRAPHING

118 primary school student teachers took part in our study. A group was formed from 64 second-year students from an undergraduate education course. They were following three different specialisms: Mathematics, Science and English. Another group of participants was composed of 54 education post-graduate (PGCE) students. The study had three main stages. Initially, we gave a questionnaire to all student teachers just before they took a data handling section in a curriculum methods course in primary school mathematics. The questionnaire consisted of items that examined their familiarity with a *reader* contexts and their background in mathematics and statistics. It comprised two tasks based on print media graphs. Secondly, we made observations of the activities developed during the data handling section. Finally, a few months after the first and second stages, we interviewed some volunteers. However, because of lack of space, in this paper we focus only on the data related to the interviews about one of the graphs.

The interview included the same graph given on the questionnaires (see Figure 1), which was chosen for three main reasons. Firstly, we anticipated that the topics associated with the graph were related to the interests of the students, most of them living and studying in or near Warwickshire. Secondly, the graphs seem to have accessible levels of complexity of mathematical relationships and concepts. Basically, the graphs present absolute and rational numbers, and percentages. Thirdly, we choose a graph which might be straightforward to interpret. However, it was hard to find a media graph which we classify as totally “clear” and “easy” for interpretation. Therefore, we recognized even though in this straightforward graph, the way in which the target has been represented might mislead the participants.

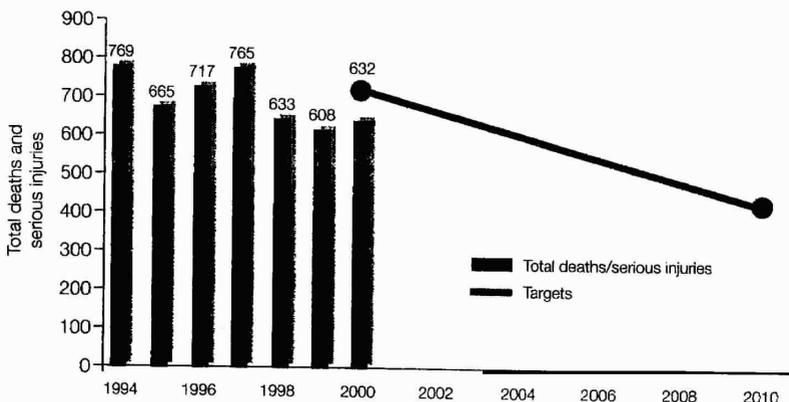


Figure 1: graph reprinted from *Quality of life in Warwickshire*, 2001, pp. 93-94.

The interviews 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 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 also were learning opportunities for student teachers to think about their own interpretation of graphs. They could also reanalyse their previous questionnaire’s answers, and discuss their expectation of teaching in graphing.

## STUDENT TEACHERS INTERPRETING MEDIA GRAPHS

Generally, the questions involving “reading the data” and “reading between the data” demanded direct answers. However, these questions provided an opportunity to the participants for carrying 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. 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 gone from 765 to 633... it’s dropped down again, but then its 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 target starting point. She seemed concerned about the graph’s structure, which is clearly associated with cognitive aspects. On the next part 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 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 than 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 a efficient application of technical procedures. Then, she started to conjecture about the social context in which the data might be related. When encouraged to specify a prediction, she recognized that it was difficult but she made a prediction.

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 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 than 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, on the following part of the interview, she demonstrated her uncomfortable feeling about 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 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 have 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 bought 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 this...?

T – Hum... I mean... Yeah... Deaths and serious injuries... there was a serious injury... and you can always class 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 than... Well, I suppose unless they... If they had a bit writing to say what, and how they 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 its... 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, 35 years 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... Than... 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 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 its death and injuries. (...) But obviously that was addressed, because there was a big drop there [1997-98]. So, I think there 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, looking at the patterns shown on the graph, the context in which the road accident 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 its obviously that's what they're hoping... I don't think its actually going to hit the bottom. I think there is always 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 in which she compared both situations of reading of the graph. But, it was a moment in which she could 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 this 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 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, even though criticising and recognising the limits of her interpretation.

## CONCLUSIONS

Our analyses of interviews indicated that the way in which we asked about predictions from the data helped the students in building an interpretation 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. 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 et al. 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, which indicated the use of what we call Critical Sense.

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 students to engage in the kind of activity in which Critical Sense may develop. A further focus of our research will be to compare characteristics of traditional pedagogic contexts with the experiences of student teachers during our interviews.

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