WHAT IS UNUSUAL? THE CASE OF A MEDIA GRAPH

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Three hundred and twenty-four middle school students considered a group of three graphs in a newspaper article about boating deaths. The graphs contained discrepancies and the students were asked to "comment on unusual features." This form of questioning produced a distribution of responses surprising to the authors and perhaps challenging to current goals for statistical literacy. Of these students, 201 answered the same question two years later and although overall performance improved to some extent there were still very few high level responses. The outcomes point to specific suggestions that can be made for middle school classrooms in line with the goals of statistical literacy.

INTRODUCTION

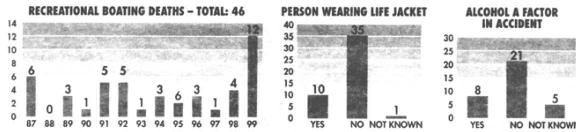
Quantitative literacy and critical numeracy have emerged as avenues for considering mathematics in a reform curriculum aimed at catering for all students (Steen, 2001); in the same way statistical literacy is taking the chance and data curriculum to a wider audience. Adults need to interpret the information with which they are inundated daily; but what are the criteria for effective decision-making? International adult literacy surveys (e.g., Dossey, 1997) have considered document literacy and quantitative literacy alongside prose literacy as significant tools required by adults in western society. The tasks employed in these surveys have a strong reliance on statistical ideas, particularly graph interpretation.

Gal (2002, pp. 2-3) suggested that statistical literacy considers people's ability to interpret and critically evaluate statistical information, and their ability to communicate their understanding, concerns, and reactions. Watson (1997) proposed a three-tiered hierarchy for statistical literacy, incorporating (i) an understanding of basic statistical terminology and tools, (ii) an understanding of these terms and tools within societal contexts, and (iii) the ability to question claims made without appropriate justification. These steps are similar to the code-breaking, text-meaning and usage, and critical thinking components associated with models of critical literacy (e.g., Freebody & Luke, 2003).

The current study arose from a larger project that was focused on school students' appreciation of variation as the foundation of the chance and data curriculum (see, e.g., Watson & Kelly, 2002, 2003). Although the aim of the larger study was to describe the development of the understanding of statistical variation, tasks were developed in contexts that employed the specific topics in the curriculum, such as chance events, averages, and graphs, and thus considered aspects of statistical literacy as well. The contexts varied, including simple settings such as rolling a die, familiar settings such as a school survey, and unfamiliar social settings such as would be found outside of school. It is for this last setting and the topic of graphs that the task discussed here was devised.

The graphs upon which the task was based are shown in Figure 1 (Haley, 2000) and were chosen for their potential for measuring aspects of statistical literacy in a context involving authentic variation. The straightforward bar graph style was considered accessible to all students at the middle school level. Having three graphs instead of one allowed features to be compared and contrasted. The context for the graphs—boating deaths in the state where the students lived—was considered comprehensible, as well as a social issue worth considering in terms of the goals of statistical literacy. There were two anomalies in the graphs that would allow students to question and display critical statistical literacy skills. There was also variation in the graphs, which was an underlying feature of the larger study.

BOATIES' SAFETY FAILURE



These graphs were part of a newspaper story reporting on boating deaths in Tasmania.

Figure 1: Set of three graphs used in the task (Haley, 2000)

Of interest was what students would attend to when examining the graphs. What aspects of the graphs would they find "unusual"? Would they be influenced by the authentic nature of a newspaper extract and be unwilling to question it? Specifically, this study examines the categories of response that characterise middle school students' descriptions of unusual features of bar graphs from the media (containing technical discrepancies). It also considers whether the responses change over a two-year period.

METHODOLOGY

Sample. The sample consisted of 156 students in Grade 7 (age 12-13) and 168 students in Grade 9 (age 14-15) at four government high schools in the Australian state of Tasmania. Of these students, 137 in Grade 7 and 64 in Grade 9 responded again two years later. Fewer students were surveyed in Grade 11 because many leave or change schools at the end of Grade 10.

Procedure. The task was Question 10 in a 45-minute written survey with 15 questions, many with multiple parts (see Watson, Kelly, Callingham, & Shaughnessy, 2003, for the full survey). It was the only question based on a bar graph or a graph from a newspaper. The instruction, "Comment on any unusual features of the graphs," was intended to motivate students to consider various aspects without being so explicit as to influence students' focus. Two large labelled spaces were provided to encourage careful consideration and reflect the plural use of the word "feature," thus permitting two responses. The task behaved well in a measurement sense (Watson et al., 2003) based on the two different hierarchical codings described below.

Analysis. For the purposes of coding the two responses were treated together. Coding was conducted by a research assistant and the first author following the development of two coding schemes. The first scheme, in Table 1, reflected the appropriateness of responses based on the information in the graph and the steps to Critical Statistical Literacy (CSL) noted earlier. The four coding levels of increasing appropriateness had various subcategories defined to reflect the diversity of responses. The second coding scheme, shown in Table 2, was based on the increasing structural complexity of responses in Appreciation of Variation (VAR). Four levels of response were defined, with one having three subgroupings. As indicated by their definitions these two coding schemes were used to reflect the different possible interpretations of the task based on the twin aims of investigating variation and statistical literacy.

Code	Sub Code	Description of Category for Critical Statistical Literacy (CSL)
0		Inappropriate responses
	0A	No response
	0B	Idiosyncratic/"nothing unusual"
	0C	Inferring from graph: Advice
	0D	Direct graph interpretation, without mentioning anything unusual
	0E	Incorrect graph interpretation of unusual data
1		Partially correct interpretation: Unusual data or graphing
	1A	Very general comments about graphing elements
	1B	Both correct and incorrect interpretations of unusual data
2		Correct graph interpretation: Unusual data or graphing
	2A	Correct but non-specific interpretation of unusual data
	2B	Specific statistical comment about graphing elements
3		In-depth graph analysis: Recognises mistakes
	3A	Identification of a mistake, but error in explanation
	3B	Correct identification of at least one mistake

Table 1: Coding scheme based on Critical Statistical Literacy criteria

Code	Sub Code	Description of Category for Appreciation of Variation (VAR)
0		No acknowledgement of variation
1		Focus on columns
	1A	Focus on a single column
	1B	Comparison across two columns
	1C	Focus on the highest column as "most"
2		Focus on increase in the data over time
3		Acknowledgement of variation

Table 2: Coding scheme based on criteria related to Appreciation of Variation

All responses had two codes associated with them, one for CSL and one for VAR. As an example, the response "That 35 people died from not wearing life jackets, 8 from alcohol" was coded as 2A in the CSL coding scheme for its non-specific interpretation of the data, and as 1A in the VAR coding scheme for its focus on single columns. The research assistant coded the responses, which were checked by the first author, with inconsistencies decided by discussion (cf., Miles & Huberman, 1994).

RESULTS

The results report students' response categories distinguished by the coding schemes for Critical Statistical Literacy (CSL) and Appreciation of Variation (VAR). Changes in response levels over two years are also reported for some students. Students' full responses have been edited in some cases to show only the salient features.

Responses for the CSL coding scheme

As shown in Table 3, a large percent of students in both Grades 7 (44%) and 9 (40%) did not respond at all to the task (Category 0A). Typical responses in Category 0B indicated nothing unusual or were idiosyncratic, such as "They all look okay to me." Some students focused on giving advice based on the information in the graphs (Category 0C), rather than something unusual; for example, "People should wear life jackets." Category 0D responses commented on something in the graph but without focusing on anything unusual, such as "The graphs show us that boats are just as dangerous as cars are." Finally, Category 0E contained responses that identified as unusual something that would not be considered unusual in a statistical sense or that was not based on information in the graph, as seen in "Hardly anyone wore life jackets in 99" or "Less people died by not wearing life jackets."

Code	0					1		2		3		
Sub Code	0A	0B	0C	0D	0E	1A	1B	2A	2B	3A	3B	Total
Grade 7	68	7	5	3	5	2	3	53	6	2	2	
Subtotals	88 (56)					5 (3)		59 (38)		4 (3)		156
Grade 9	67	9	0	4	0	2	8	61	13	2	2	
Subtotals	80 (48)					10 (6)		74 (44)		4 (2)		168

Table 3: CSL categories: number (percent) for each grade

At Level 1, responses were partially correct and addressed unusual data or the format of the graph. Category 1A responses made very general or vague statements, such as "They're all different graphs. They're [sic] all got different meanings." Category 1B responses included both correct and incorrect interpretations. One student wrote "Most people drowned in 1999. A lot of people were tanked [drunk]."

Responses at Level 2 reflected what students considered unusual features of the data or graphs but which were not related to the errors therein. In category 2A were non-specific comments about the unusual nature of the data. Examples include "The number of deaths has risen over the years." The other subcategory of Level 2 (2B) was much smaller, consisting of at least one comment on something unusual about the graphs themselves; for instance, "The way they're set out. They don't have anything telling you what the Y and X axes are."

Of the Level 3 responses that found mistakes, the first group (3A) made errors in reporting these, e.g., “Well on graph 1 it says there is a total of 46 but I counted and it has only got 38.” In the final group (3B), responses focused correctly on the discrepancies in the graphs, such as “The first graph has a mistake, the 6 is on 2.”

Responses for the VAR coding scheme

Level 0 responses for the VAR coding summarized in Table 4 included both non-responses and responses that had no comments that would indicate a student had considered change or variation in the graphs. Many of the latter, such as “The first one says total: 46, but the graph shows 50 people” may have been placed at much higher levels in the CSL coding.

Code	0	1A	1B	1C	2	3	Total
Grade 7	89 (57)	40 (26)	3 (2)	14 (9)	4 (3)	6 (4)	156
Grade 9	97 (58)	26 (15)	13 (8)	22 (13)	5 (3)	5 (3)	168

Table 4: Variation categories: numbers (percent) for each grade

At Level 1 there were three subcategories focusing on columns. In the first (1A), attention was given to a single column. One student wrote “35 people weren’t wearing a life jacket. Tonnes of people keeled over [died] in ’99.” Category 1B responses considered two columns: for example, “From ’87 the deaths have shot up from 6 to 12”. In the third group (1C), responses focused on the highest column as “most”, as exemplified in “There were more deaths in ’99 than any others.”

Level 2 responses recognised increases in the data over time, and included “The number of deaths has risen over the years.” Level 3 responses made a comment relating to the variation, such as “Most of the people who die were spread out but there was a major increase in ’99.”

Change in response categories over two years

Table 5 shows the categories of responses related to CSL for the subgroup who completed the survey two years later. There was some improvement, with fewer students responding at Level 0. The Grade 7/9 students performed better than the original Grade 9 cohort, due to an increased number of Level 1 responses. Both groups showed a small increase in the number of Level 3 responses, and the Grade 9/11 students also increased their number of Level 2 responses.

For students with complete data across both years, 43% of Grade 7/9 and 56% of Grade 9/11 responded at the same level (0 to 3), whereas 39% of Grade 7/9 and 26% of Grade 9/11 improved. One Grade 9 student who had originally written “Too many recreational deaths. Not many alcohol related deaths” (2A) gave the following Category 0C response two years later: “People wearing a life jacket, in sheltered waters in a boat under 6m should always have a life jacket.” A Grade 7 student who had originally identified a discrepancy in the graph (3B) later focused only on specific aspects of the data, saying “a lot of people die in 1999” (2B). One Grade 7 student who initially focused on specific data elements in writing "Not many people had life jackets. Tons of people drunk" (1B), identified the error in the graph totals in his longitudinal response (3B). A Grade 9 student who gave no response at all in the initial survey later engaged in the task with a Category 1B response: "99 results are extremely high all of a sudden. Alcohol was the cause for almost half."

Code	0					1		2		3		
Sub Code	0A	0B	0C	0D	0E	1A	1B	2A	2B	3A	3B	Total
Grade 7/9	27	1	2	5	6	0	29	50	5	7	5	
Subtotals	41 (30)					29 (21)		55 (40)		12 (9)		137
Grade 9/11	7	5	1	3	2	0	7	26	7	3	2	
Subtotals	18 (28)					7 (11)		33 (52)		6 (10)		64

Table 5: CSL categories — Longitudinal survey (cf. Table 3)

Table 6 reports on similar data but for the VAR coding. Again there was some improvement over the two-year period, and once more the Grade 7/9 students performed better than their earlier Grade 9 counterparts. Most of the change was due to increased numbers in Category 1C and Level 2. Responses clearly articulating variation across the graphs (Level 3) were still rare; however some of them indicated a significant change for some individuals. One Grade 7 student's response in the first survey—"I can't see anything in them. I don't know what the 87 to 99 means"—was coded low on both CSL and VAR, but the student's response in the second survey recognized that the range is big (Level 3). Another student initially could identify particular data elements, and then two years later had a more holistic view, writing "I think that the graph 'Recreational boating deaths' was fairly inconsistent throughout the years and had a sudden jump at the end (99)" (Level 3).

Code	0	1A	1B	1C	2	3	Total
Grade 7/9	47 (34)	30 (22)	15 (11)	20 (15)	17 (12)	8 (6)	137
Grade 9/11	23 (36)	10 (16)	2 (3)	14 (22)	11 (17)	4 (6)	64

Table 6: VAR categories — Longitudinal survey (cf. Table 4)

For students with complete data across both years, 43% of Grade 7/9 and 44% of Grade 9/11 responded at the same level (0 to 3), whereas 45% of Grade 7/9 and 32% of Grade 9/11 improved. There were some who declined quite markedly from the first survey to the second. This includes students who recognized variation initially but who, in the second survey, focused on single columns (e.g., "In 99 they went up but they should have been down because of the new technology and laws") or claimed not to see any "unusual features" at all. Considering both CSL and VAR, no student changed from Level 3 on one to Level 3 on the other. Overall, 14% performed at Level 3 on at least one (one student did so on both).

DISCUSSION

The importance of variation and critical statistical literacy

If the task had been more specific—targeting a particular aspect of either variation or statistical literacy—larger numbers of students may have given higher level responses. It is important to recognize, however, that in articles like that used as a basis for the task and in much of the data encountered daily in the real world, the data come with no questions at all. Accompanying reports often present the writer's interpretation, which may be biased or incorrect. Moreover, as seen here, the actual data as presented come with no guarantees of correctness. Given this, the results of this study are of concern, since students appear to lack strategies for searching for the "unusual". They rarely query the data or examine the data in a holistic way. For the students in this study, the kind of critical thinking suggested by Gal (2002) and explicated as the third step of Watson's 1997 hierarchy seems to be uncommon.

For the CSL coding, 40% to 50% of the students could make generally meaningful comments about what the graphs were showing or, to a lesser extent, could identify technical shortcomings in the graphical presentation. In contrast, a similar number either made no comment at all, or could attempt only vague descriptions. As seen in Tables 3 and 5, less than 10% of the students appeared to check the data in any way for consistency. Presumably the remaining students took the data at face value.

Performance in relation to the VAR coding was similarly disappointing, with well over half of the students in the first survey not considering the variation in the graphs as something that might be regarded as unusual. If variation was acknowledged at all, in most cases it was because students identified particular values, notably extreme values. Students rarely identified—or, at least, commented on—trends or variation in data. There seems to be an inability (or unwillingness) to step back from individual data points in the graphs to make meaning on a larger scale. Those who commented on variation generally gave enough discussion in their response to warrant a Level 2 classification on the CSL coding, but those few who identified errors (at Level 3 on the CSL scale) usually were at only Level 1 on the VAR coding.

Implications for teachers

The results suggest that there has been a lack of attention to variation and statistical literacy with respect to graphs in the media. It is suspected that students are given opportunities to construct graphs based on data, to comment on the technical presentation of existing graphs, and to read off values from graphs and tables, but that critical evaluation and higher level analysis are rarely explicitly fostered. Examples such as the boating deaths graphs used here are not rare in the media, but students need activities that help them to focus on whether the data are internally consistent, whether there are unusual values, whether there are any trends in the data, and how the data vary. Most importantly, they need to make meaning from the data. Teachers can model the kinds of questions that students could and should ask when examining data. A discussion might proceed along the following teacher-directed sequence, depending on students' intermediate responses. "What story do the graphs tell? … Is there anything about them that you consider unusual? … Are there any mistakes in the graphs? … How might you tell the story better?"

Limitations and directions for future research

It should be noted that some students may have lacked motivation to respond seriously to the task, as indicated by some terse or coarsely expressed responses. The authors are also aware that some students may not have been able to express themselves clearly or in detail when completing a written survey, especially given its length. The use of an interview setting is likely to provide richer data. It would also be interesting to use the task with adults, because their experience of real world data since leaving school may affect the kinds of things they perceive as unusual. Finally, can explicit instruction in looking for the unusual in data help students make this their usual approach to examining statistical material?

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References

Dossey, J. A. (1997). National indicators of quantitative literacy. In L. A. Steen (Ed.), *Why numbers count: Quantitative literacy for tomorrow's America* (pp. 45-59). New York: The College Board.

Freebody, P., & Luke, A. (2003). Literacy as engaging with new forms of life: The 'four roles' model. In G. Bull & M. Anstey (Eds.), *The literacy lexicon*. (2nd ed., pp. 51-65). Frenchs Forest, NSW: Prentice Hall, Pearson Education Australia.

Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International Statistical Review, 70,* 1-51.

Haley, M. (2000, March 30). Boaties' safety failure. *The Mercury* (Hobart, Tasmania), p.7.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Watson, J. M. (1997). Assessing statistical literacy using the media. In I. Gal & J. B. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 107-121). Amsterdam: IOS Press and The International Statistical Institute.

Watson, J. M., & Kelly, B. A. (2002). Variation as part of chance and data in grades 7 and 9. In B. Barton, K. C. Irwin, M. Pfannkuch, & M. O. J. Thomas (Eds.), *Mathematics education in the South Pacific* (Proceedings of the 26th Annual Conference of the Mathematics Education Research Group of Australasia, Auckland, Vol. 2, pp. 682-289). Sydney, NSW: MERGA.

Watson, J. M., & Kelly, B. A. (2003). Statistical variation in a chance setting. In N. A. Pateman, B. J. Dougherty, & J. Zilliox (Eds.), *Proceedings of the 27th Annual Conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 387-394). Hawaii, USA: PME Program Committee.

Watson, J. M., Kelly, B. A., Callingham, R. A., & Shaughnessy, J. M. (2003). The measurement of school students' understanding of statistical variation. *International Journal of Mathematical Education in Science and Technology, 34,* 1-29.