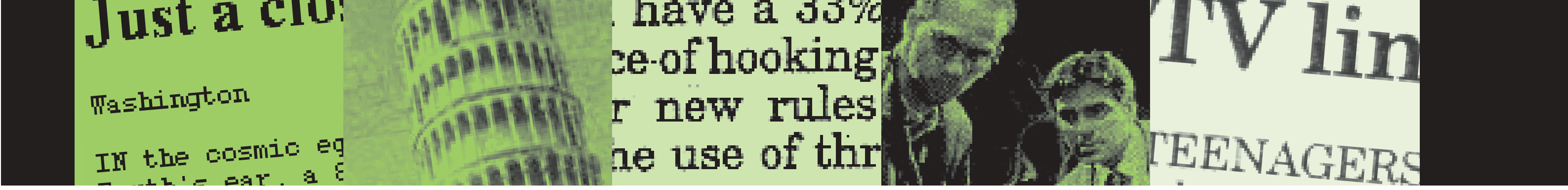


QUANTITATIVE LITE

An Arena for P

Is problem solving passé? In line with the constant need to invent new terminology in order to be at the front line of educational innovation, problem solving may be in decline as a flag bearer. Those of us who have seen problem solving evolve from closed arithmetic sentences involving two numbers to open-ended multiple-answer research projects, however, hope that problem solving is still alive and well. Perhaps the challenge is now related to finding ever more creative contexts within which to develop problem solving skills.

On the surface the introduction of numeracy as a component of the school curriculum may appear to have little to do with problem solving, for after all is not numeracy restricted to basic skills? The AAMT's own definition of numeracy firmly answers this question in the negative and offers hope for a liaison with problem solving.

> To be numerate is to use mathematics effectively to meet the general demands of life at home, in paid work, and for participation in community and civic life. In school education, numeracy is a fundamental component of learning, performance, discourse and critique across all areas of the curriculum. It involves the disposition to use, in context, a combination of:
>
> - underpinning mathematical concepts and skills from across the discipline (numerical, spatial, graphical, statistical and algebraic);
> - mathematical thinking and strategies;
> - general thinking skills; and
> - grounded appreciation of context.
>
> (AAMT, 1997, p. 15)

Numeracy, however, is not part of the title of this article! Is the term numeracy also threatened with being overtaken, this time by the phrase quantitative literacy? Perhaps not yet in Australia, although the latter term has received greater attention in the United States with books like Steen's (2001), *Mathematics and Democracy: The Case for Quantitative Literacy*. Given the moves toward incorporating multiple literacies in the reform curricula of several Australian states (e.g., Education Queensland, 2000), it would appear important to put quantitative literacy on the agenda in Australia and note its close association with the AAMT's understanding of numeracy. The International Life Skills Survey defines quantitative literacy as

> An aggregate of skills, knowledge, beliefs, dispositions, habits of mind, communication capabilities, and problem solving skills that people need in order to engage effectively in quantitative situations arising in life and work. (Steen, 2001, p. 7)

In this definition problem solving gets a mention but Steen's emphasis is overwhelmingly on context, which picks up the final point of the AAMT definition of numeracy: 'In contrast to mathematics, statistics and most other school subjects, quantitative literacy is inseparable from its context' (Steen, 2001, p. 17). Although it now appears that numeracy and quantitative literacy can be used interchangeably, the term quantitative literacy is used in this article to reinforce its importance in catering for reform-based curricula in Australia. Also the medium chosen for the problems discussed here is the newspaper,

RACY IN THE MEDIA
roblem Solving

which conjures up an accompanying need for literacy skills.

The purpose of this article then is to tie together our traditional views of the importance of problem solving with the current aims of numeracy and quantitative literacy. In doing this consider another angle on the development of quantitative literacy. Watson (1997) suggested a hierarchy for the related field of statistical literacy, which is easily adapted in the wider milieu. The hierarchy suggests three tiers or steps in the development of the goal of quantitative literacy.

- **Tier 1**
  The terminology needs to be understood.
- **Tier 2**
  This terminology then needs to be understood within the social (or scientific) context in which it is used.
- **Tier 3**
  There needs to be a critical awareness that prompts questioning of claims in context that are made without proper justification.

It is interesting to note that within the literature on critical literacy, Freebody and Luke (2003) suggest a similar framework with respect to the practice of reading. They claim there are four practices involved in reaching the goal of effective literacy: coding practices, text-meaning practices, pragmatic practices in using text, and critical practices analysing and transforming text. The first fits with Tier 1 above, the next two with Tier 2, and the last with Tier 3. The question, however, may be, is this related to the problem solving skills we want students to develop at school? I would say 'yes' in today's environment. The approaches illustrated in this article reflect a range of problem solving practices structured by the above quantitative literacy hierarchy and critical literacy practices. The approaches are exemplified based on selected newspaper articles illustrating the range of topics and mathematical content available, as well as specific links to quantitative literacy practices. Choosing humorous, seasonal, or sports articles may be particularly motivating for some classes, as are articles with a local flavour. Most chosen here are more global in nature, suggesting opportunities for many cross-curricular links. Although any medium that reports on current affairs can be used for problem solving, newspapers (and their web site extensions) are a convenient source that can be used nearly any day.

What does a good article provide as a starting point for problem solving? Several possibilities arise: a motivating context for the age group; a controversial claim; a suspicious claim; a startling graphical presentation; many numbers, measurements, or data values; or incomplete information suggesting questions. The potential for news articles is further enhanced because rarely does an article actually state a 'problem' in the form students would expect from their experience with text books. There is hence the opportunity for problem posing as well as problem solving. The first decision teachers may have to make is whether they make up the problems based on the newspaper article, or whether the students are given this task.

All examples are associated with articles from my local newspaper, *The Mercury*, in Hobart, Tasmania. The level of mathematics appropriate for an article obviously varies and the choices show what is possible at different grade or ability levels. Although it is better to use local sources, *The Mercury* provides a web site, called 'Numeracy in the News', with many articles and suggestions for their use (HREF1).

Just a close shave: Basic numeracy

The article shown in Figure 1 provides a starting point for various levels of problem solving that stresses the need for basic quantitative literacy skills. Five possible approaches are suggested.

First, in Tier 1 where understanding and code breaking are the aim, students can be set the problem of finding all of the different uses for number in the article, e.g., length, date, and distance. As fractions do not appear in newspaper text very often, this article provides an excellent opportunity to discuss the meaning of fractions in context, where they actually tell part of the story. This could lead to the task of drawing a scaled diagram of the earth and moon with the distance to the asteroid labelled in two different ways (a fraction of the total distance and as a absolute measure with units). The connection with the part-whole nature of fractions can be reinforced.

Second, in Tier 2 with respect to making meaning of text, this article can be used to help students realise the absolute necessity to have quantitative awareness when reading the newspaper. One idea would be to present the article to students with the numbers (800m, August 7, 2027, 19,000, and 1/12) removed and ask them what problems arise in making meaning without this information. Students could be asked to suggest 'reasonable' numbers to fill the gaps and compare their answers with others. For some students this exercise and the accompanying discussion are genuine problem solving activities. At the very least they should lead to an appreciation of the critical role the numbers play in getting a message across.

Third, students can be asked to use this article as a basis for writing problems for each other. This task requires literacy as well as numeracy skills. The questions posed will range from easy to difficult and some may perhaps be unsolvable, but they will inform the teacher about the students' abilities to use their quantitative literacy skills. It is likely that the problems posed will be situated in Tier 2 of quantitative literacy with a focus on pragmatic practices in using text and basic skills. Some possible problems include the following.

1. How many days is it from today until the day the asteroid is expected to arrive?
2. How old will you be when the asteroid arrives?
3. How many times wider than the classroom is the asteroid?
4. Using the information in the article, about how many miles is it to the moon from earth?
5. How many kilometres will the asteroid be from the earth at its closest?
6. If the asteroid were roughly spherical, what would its volume be in cubic metres?
7. If the asteroid were roughly cubical, what would its volume be in cubic metres?

Notice how many different quantitative skills are required to solve these problems. Some of the questions might be used to justify to students the importance of various topics in the mathematics curriculum.

Further, some of the problems above point to specific lessons that could be structured around the article. A fourth possibility hence is to use such problems, developed either by

> **Just a close shave**
>
> Washington
>
> IN the cosmic equivalent of a bullet whizzing by Earth's ear, a 800m-wide asteroid looks as if it will come closer to smashing into our planet than any other space rock astronomers have tracked.
>
> It won't hit Earth, but its arrival on August 7, 2027, will be a reminder that space can be a dangerous place. NASA scientists and other astronomers determined this week that the asteroid could swing as close as 19,000 miles to Earth's surface—only 1/12 the distance between here and the moon.

Figure 1. The Mercury, 22 May, 1999, p. 25.

other students or the teacher, as motivators for the study of topics such as

a) working with fractions and ratios,
b) converting units (e.g. imperial to metric), and
c) finding volumes.

Starting with media-based problems may expose gaps that teachers did not realise existed. Articles can also be used as assessment tasks. Again this supports the building of skills in the pragmatic use of problem solving in context.

Fifth, it is of course possible to extend the objectives of problem solving related to quantitative literacy, to the area of science. Students could be asked to do some research to find out about asteroids, what they are made of, their likely impact if they hit the earth, and the theories on their impact in the past. As well students could collect information on the distance from the earth to the moon in order the check the validity of the figures given in the article. As the distance from the earth to the moon varies over time, this may not be a trivial exercise. It should introduce the idea of average distance and students can use their estimation skills to make a judgment about how accurate the fraction 1/12 is to describe the 19 000-mile distance in terms of its relation to the distance to the moon. Writing a report on what has been learned is an important final step in this approach. Depending on specific outcomes, this aspect of problem solving can reflect either Tier 2 or Tier 3 objectives of quantitative literacy.

The Leaning of the Tower of Pisa: Scale drawings and trigonometry

The article shown in Figure 2 can be treated with the same range of problem solving activities as the one in Figure 1. Identifying quantitative expressions, for example, as related to quantity, linear measurement, angle measurement, or order, will be a non-trivial task for some students in terms of using the text. The potential to access higher levels of the mathematics curriculum, however, is greater for this article. Using scale drawings and trigonometry, with information from the article and measurements from the photograph, it would be possible to pose many problems or to introduce these topics as the focus of lessons. Again leaving out the numbers indicates how important quantities are to develop a rich description of the Leaning Tower of Pisa. As an open-ended problem solving task, there is also the opportunity for students to do their own research on the tower (e.g., HREF2).

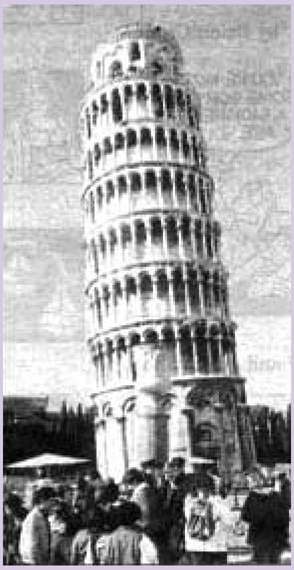
> **New slant on old landmark's story**
>
> Pisa, Italy
>
> THE Leaning Tower of Pisa is leaning a little less thanks to an experiment aimed at making the monument settle better into the ground.
>
> In February, workers started removing soil from under the tower's base. The digging was carried out through 12 tubes inserted 6m into the ground.
>
> Going into the experiment, the 12th-century tower leaned some six degrees—4m—off the perpendicular.
>
> Experts yesterday reported that the tower had since straightened by 5mm.
>
> "The results of the experimental excavation are superior to the expectations," said Michele Jamiolkowski who heads a committee which has monitored measures aimed at keeping the tower from toppling over.
>
> 
>
> Before the digging began, two sets of steel "suspenders" anchored to giant winches dug into the ground about 100m from the tower were attached to the monument. Should the excavation threaten to make the structure wobbly, the suspenders would be pulled tight.
>
> AP

Figure 2. The Mercury, 24 May, 1999, p. 13

Heartless television: Confidence intervals

Although the article in Figure 3 could be used as a catalyst for discussion in a Media Studies course, it also lends itself to some rather more specific problem solving than the previous two articles in relation to both Tier 2 and Tier 3 of quantitative literacy. First there is the opportunity to apply understanding in a pragmatic context and second there is the chance to use this outcome to comment on the implied criticism in the article.

In a mathematics class the question for the statistics unit is whether there is a significant difference between the survival rate for the TV episodes and that for actual 'real world' situations. One could ask whether the 'sample' of 97 episodes is representative of a population whose resuscitation rate is at most 30%. For students in the senior secondary years this question could be answered for example with a z-test based on the sample of size 97 with a value of 77%, compared to the 'population' rate of 30% outside hospitals (Moore & McCabe, 1993). To test this, calculate

$$z = \frac{(\hat{p} - p_0)}{\sqrt{\left(\frac{p_0(1-p_0)}{n}\right)}} = \frac{(0.77 - 0.30)}{\sqrt{\left(\frac{0.30(0.70)}{97}\right)}} = 10.10$$

This extreme value would lead to the rejection of the hypothesis that the TV sample is from a 'real world' population. The problem could also be solved by finding a 95% confidence interval around the 'sample' value of 77% and seeing if this includes 30%. Again this is unlikely but the problem is a nice exercise. The estimate of the standard error of $\hat{p}$ = 0.77 from the sample is

$$\sqrt{\frac{0.77(0.23)}{97}} = 0.0427$$

and the 95% confidence interval is

$(0.77 - 1.96 \times 0.0427,\ 0.77 + 1.96 \times 0.0427)$
$= (0.686,\ 0.854)$,

which certainly does not contain the claimed population value.

This problem is 'closed' in comparison to the earlier two scenarios but it still provides a motivating environment in which to assess students' ability to use z-tests or confidence intervals, as well as show the usefulness of statistics in supporting the reporter's claim.

Heartless side to television heroics

UNREALISTIC recoveries regularly portrayed in widely-viewed television shows such as ER, Rescue 911 and Chicago Hope may be a catalyst for pressure on real-life doctors to perform resuscitations doomed to failure, researchers say.

Cardiopulmonary resuscitation (CPR) saves no more than 30% of cases outside of hospitals and just 15% of patients inside hospitals, this week's New Scientist magazine said.

But in 97 episodes of the three shows watched by researchers at a North Carolina medical centre, 77% of patients given CPR were revived.

CPR is most frequently performed on older patients already in hospital.

But in the more colourful televised versions, subjects were usually strapping young male and female victims of car crashes or shootings.

Research group team leader Susan Diem has called on television producers to inject more realism into their CP dramas.

But she acknowledges it's unlikely about three quarters of television doctors' patients are likely to be sacrificed to realism.

"It would be kind of a downer and we understand that," she said.

AAP

Figure 3. The Mercury, 27 June, 1996, p. 20

Extra fly: Innumeracy

Occasionally an article like that shown in Figure 4 provides the opportunity for a brief problem solving encounter with critical practices in Tier 3 of quantitative literacy. Where has the reporter gone wrong? The outcome could be a class letter to the editor of the newspaper pointing out the misreporting of the part-whole relationship associated with increasing the number of flies allowed on a fishing line from two to three. Although questioning a claim is a Tier 3 goal, the explanation is likely to be a Tier 1 problem solving exercise for many students in relation to their part-whole understanding of percent. Several connections are possible as the relationship of an increase of one to the original total of two is seen as the key to a 50% increase. Also important for some students is a discussion of why the reporter may have become confused.

Extra fly a boost for Tasmanian anglers

By STEVEN DALLY
Chief Political Reporter

TASMANIAN flyfishers could have a 33% better chance of hooking a trout under new rules allowing the use of three flies for the new season.

Or anglers could just have a 33% higher chance of hooking themselves in the back of the head.

The new rules lifting the fly limit from two to three were unveiled yesterday by Primary Industries, Water and Environment Minister David Llewellyn for the opening of the new trout season from midnight on Friday.

The Mercury's freshwater fishing writer Harvey Taylor said the three-fly limit followed a rise in the popularity of British "loch-style" fishing from a drifting boat.

"It is another discipline of the sport that is coming into vogue," he said. Mr Taylor said he was not an advocate of three-fly rigs although the method had its followers.

"It is a difficult way to fish and most people can get into enough trouble with one fly," he said.

Figure 4. The Mercury, 28 July, 1999, p. 5

TV link to teen violence

TEENAGERS who watch more than an hour of television a day are more likely to be violent in later life, researchers say.

Assaults, fights and robberies increased dramatically if daily TV time exceeded three hours, said researchers at Colombia University and the New York State Psychiatric Institute, who studied more [than] 700 people for 17 years.

Parents should avoid letting their children watch more than one hour of television a day during early adolescence, a spokesman said.

Figure 5. The Mercury, 30 March, 2002, p. 4

Television and violence: Cause and effect

The social issues associated with the article in Figure 5 are complex and experts have argued about the association of television viewing and violence since the advent of the medium. This short article creates more problems than it solves in its presentation and this is one of the main reasons for using it in the classroom. In the first instance it can be used as a problem posing exercise. What does the reader need to know about the research study before making a judgment on the findings? This should create wide discussion in a senior level class that has been discussing issues of statistical design and drawing conclusions from data sets. Some of the issues that should be considered include the following, which reflect Tier 2 and Tier 3 objectives of quantitative literacy.

- How much more likely are those who watch more than one hour of TV than those who watch less, to be involved in violence?
- Did the study distinguish 'more than one hour' from 'more than three hours'?
- How were the people studied for 17 years?
- How old were the people at the beginning?
- What population did the sample represent?
- What efforts were made to control for other factors that might affect violent behaviour, like parental neglect, family income, psychiatric problems?
- What was the attrition rate within the sample over the 17 years?
- How does the language used imply that there is a cause-effect relationship operating?

As it stands this short article is only useful for problem posing by students. Many of the problems will not even involve numbers. Regardless of some people's perceptions of what mathematics is about, this is a good trend in the mathematics classroom and reflects precisely the issues raised by Steen (2001). Specific literacy skills can also be developed in expressing these ideas in writing.

In today's world, however, this should not be the end of the problem! An inadequate print report should lead students at least to the Internet to see what other information is available to assist in answering questions like the above. At least two possibilities emerge: a keyword search using an Internet search-engine with words like 'television', 'teenagers', 'violence', 'New York', and 'Columbia University'; or a link to a well-known newspaper such as *The New York Times*. I found four articles in a very short time from *The Philadelphia Inquirer*, *The Washington Post*, *The Los Angeles Times*, and CNN Medical Unit. In comparing these longer reports it was of great interest to compare and contrast the information and views presented in the four sources. Although there was overlap, each source provided at least one piece to the puzzle not provided by the others. This is a significant point for students to discover, particularly in an area like this where a definitive answer from the data is unlikely to be forthcoming. The other sources did, however, provide the missing link to the original source of the study, the journal *Science* (Johnson, Cohen, Smailes, Kasen & Brook, 2002).

This is a particularly important example because although encouraging students to pose problems, and through the Internet finding partial solutions to many of the problems posed, there is no final answer to the statistical question of cause and effect. This is what happens in 'real world' problem solving and the mathematics classroom should be no different. Decisions are made based on the best information available. This is where quantitative literacy comes into its own: the final step in the problem solving task should be a student-written report that argues both sides with supporting evidence and displays an understanding of the cause-effect association that is proposed. A similar problem solving experience can be created based on a claimed association between heart deaths and automobile usage, as suggested by Watson (2000).

Conclusion

It is hoped that almost all levels of problem solving in relation to quantitative literacy can be catered for with the approaches suggested here. Although the presentation of articles with errors, like in Figure 4, or suspicious claims is motivating and developing critical quantitative reading skills is important, we must be careful to avoid only giving bad examples of numeracy in the media. Students also need to develop positive habits of interpretation.

In the current context of debate about quantitative literacy as a part of multiple literacies, it is important for mathematics teachers and mathematicians to put forward structured arguments and examples to show the importance of the contribution that quantitative literacy can make. It is not sufficient to cop-out like the mathematician Wade Ellis who said, 'For me, quantitative literacy is more like art than science. I know it when I see it, but I cannot easily define it' (2001, p. 63). It may not be easy but we must try.

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Acknowledgement

The author would like to thank an anonymous referee for helpful comments on revising this article.

The images shown in this article appear courtesy of *The Mercury* newspaper, Hobart.

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