STATISTICAL LITERACY AND ADOLESCENT RISK

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In the preparation of adolescents to make informed life decisions, programs educate students about the risks associated with many personal behaviours. Topics related to wider social risk are also included in other areas of the school curriculum, such as science, social science and environmental studies. There are various aspects of statistical literacy required to understand expressions of risk. Statistical literacy includes an understanding of chance measurement, of the contexts in which risk statements are expressed, and of how statistical relationships might be (mis)used to infer cause-effect relationships or to predict individual outcomes. Related factors may include confidence and understanding of conditional language.

Adolescent risk-taking behaviours have been the focus of educational programs in an attempt to discourage adolescents from engaging in behaviours that involve health risks. Research has shown, however, that education programs which increase knowledge levels in students are not always accompanied by a reduction in risk-taking behaviour. The extract from a newspaper article shown in Figure 1 is an example of this concern. It is interesting to note that the title implies "the message" is not "getting through," while the final paragraph suggests that *some* sort of message is getting through in *some* sense. This article is just one example of a health risk where educators need to question just what messages are being presented, how students are interpreting them, and why this is not translated into behavioural change.

Call for shock tactics to get message through

SOAKING up the rays at the Hobart Aquatic Centre, this group of Tasmanian teenagers seems decidedly blasé about the risk of skin cancer. [...]
Sandy Bay GP and state cancer council board member Rob Walters said he believed a shock campaign was needed to alert teenagers to the risk of excessive exposure to the sun.
The teenage years were the years of believing nothing bad could happen to them — even though they knew the facts.
"The survey shows the message is getting through but there is the age-old problem of how do we actually change their behaviour rather than just presenting the effects," Dr Walters said. [...]

Figure 1. A newspaper extract (L. Sutherland, *The Mercury*, 25 January 1998, p. 7).

RISK IN THE SCHOOL CURRICULUM

The concept of risk is frequently used in the Australian health and physical education curriculum (e.g., Australian Education Council [AEC], 1994a, 1994c). In *A Statement on Health and Physical Education for Australian Schools* (AEC, 1994a), the strand "Human functioning and physical activity" includes a section concerning "Challenge, risk and safety," in which

> Students examine the concept of risk, including real and perceived risk, and how this relates to different situations. They identify factors that influence risk-taking, and explore how inappropriate risk-taking presents dangers. They learn about the causes and consequences of different behaviours and the potential risks to safety related to, for example, substance use, sexual practices, participation in physical activities, and road behaviour. (p. 14)

Specific outcomes for "Safety" in *Health and Physical Education - A Curriculum Profile for Australian Schools* (AEC, 1994c) include the following.

3.12 Demonstrates strategies that deal with unsafe or emergency situations.
- Identify and practise ways of responding to pressures on them to try various substances and risky behaviours. (p. 55)

4.12 Assesses options and consequences in responding to unsafe situations.
- Predict the consequences of inappropriately using substances such as alcohol, medications, and other drugs.
- Explain how the consequences of taking risks can influence future judgements. (p. 69)

5.12 Evaluates behaviours that influence personal safety and that of others.
- Assess the degree of risk associated with an activity or situation by finding out and telling others the relevant facts. (p. 87)

Understanding of risk also appears in other areas of the curriculum. For example, *A Statement on Science for Australian Schools* (AEC, 1994b) suggests that "Working scientifically" involves students

- Considering positive and negative personal, social, economic, technological and environmental implications of scientific knowledge and its uses; assessing the implications of uncertainty; analysing risk... (p. 17)

Given the widespread inclusion of risk across curriculum areas, it is somewhat surprising, in turning to the mathematics curriculum, that although *A National Statement on Mathematics for Australian Schools* (AEC, 1991) has a strand devoted to "Chance and Data," there is only brief mention made of "risk."

- Seek from appropriate sources information concerning the risks involved in certain situations (e.g. the risk of accidents per 1000 km travelled for different modes of travel). (p. 171)

Even more disconcerting is that no reference is made to "risk" in the curriculum profile (AEC, 1994d), nor in the United States' *Curriculum and evaluation standards for school mathematics* (National Council of Teachers of Mathematics, 1989). Can educators afford to continue to ignore addressing students' statistical literacy which may affect understandings of risk, and ultimately decisions involving risk-taking behaviours?

STATISTICAL LITERACY

While educating about risk should continue to address factors such as perceptions of values of behaviours and their outcomes, social pressure, self-esteem and locus-of-control, mathematics educators must educate students about statistical aspects. Statistical literacy is required for reading news articles and other information based on statistical data, to understand expressions of the mathematical assessment of the degree of risk involved in a situation. Watson (1997) has suggested a hierarchy of statistical literacy which may assist in understanding concepts necessary to interpret risk. The hierarchy involves three tiers: (1) having knowledge of basic statistical terms, (2) recognising these and interpreting them in applied contexts, and (3) being able to question unrealistic claims made by the media or others. Several aspects of statistical literacy emerge in terms of educating adolescents for evaluating risk situations.

1. Statistical literacy to understand probabilities associated with risk statements.
2. Statistical literacy to interpret statements in context. This may include identifying conditions for which the statements hold and determining the personal relevance of these conditions, or understanding associations among empirical data upon which such statements are based.
3. Statistical literacy to question inferential claims, addressing threats to validity such as methods of sampling and data collection, or inappropriate inferences from data.

These three aspects of statistical literacy are discussed later.

RISK MEASUREMENT

Watson, Collis and Moritz (1997) describe three levels in the development of

understanding chance measurements: (i) a recognition of basic uncertainty, that "anything can happen," (ii) qualitative measurement, based on more, less, or equally likely, and (iii) quantitative measurement, based on numerical expressions using concepts of ratio, fraction or percentage. Many adolescents, even at Grade 9 level, responded to questions in the first two levels of development. As well the influence of belief and psychological factors, e.g., related to luck (Watson, Collis and Moritz, 1995), may be relevant in considering adolescents' basic understanding of chance measurement. Could it be that adolescents who approach situations of risk with a level (i) view of basic uncertainty become fatalists, reasoning that outcomes are just luck, and that behavioural decisions do not affect the chances of various outcomes? If so, this may be associated with perceived lack of control (or external locus of control). Such an interaction between statistical literacy and psychological factors in interpreting risk and making behavioural decisions is in need of investigation. Articles such as the one shown in Figure 2 may help to reinforce this view, and at best, only encourage a level (ii) appreciation of relative likelihood rather than numerical chance measurement.

Oz early asteroid alert at risk of crashing

SCIENTISTS meet today to discuss the threat posed by an asteroid hitting Earth amid claims that the British government has failed to wake up to the risk and hasn't supported an Australian early warning project.
Experts believe the chances of being killed by an asteroid impact is four times higher than that of dying in a plane crash. [...]

Figure 2. A newspaper extract (*The Mercury*, 12 November 1996, p.15).

RISK CONTEXTS AND RELEVANCE

Risk statements often use conditional language to refer to differential risks under different conditions. The headline shown in Figure 3 attempts to convey a clear message to deter people from smoking as it causes wrinkles, but complicated conditional statements follow. The conditions themselves require interpretation — should one equate all durations of less than 49 years? How should adolescents consider the relevance of avoiding wrinkles when the condition is "more than 50 years"? The context of the risk statement becomes an important part of interpretation.

Wrinkles ultimate smoking deterrent

A study found that those who smoked a pack of cigarettes a day for less than 49 years doubled the risk of premature wrinkling. For more than 50 years, the risk was 4.7 times greater than those who do not smoke. [...]
He said he was not sure if the wrinkling could be reversed if people quit smoking. "'You're going to be old and ugly before your time if you smoke,' may be just the message that leads them to throw away their cigarettes for good," he said.

Figure 3. A newspaper extract (*The Mercury*, 16 May, 1991, p. 1).

Risk statements also are often based on a statistical association which itself needs to be understood in context. Walker (1994) describes the conceptual gulf that exists when people do not see any link with empirical data to support probability statements.

> [W]ith respect to probability assertions, risk assessment scientists often incorporate an "objectivist" or "relative frequency" interpretation of probability into their risk estimates, and derive those estimates primarily for groups. Non-scientists, by contrast, are likely to adopt a "subjectivist" or "degree of confidence" interpretation of probability when estimating their personal risks, and either misunderstand or significantly discount the relevance of the conclusions of risk assessment scientists.

Three different views of probability are described by Kapadia (1986): (i) a classical view, based on a theoretical assumption of equal likelihood, (ii) a frequency view, based on long-term empirical data, and (iii) a subjective view, based on personal belief. How often do mathematics educators lead students to make appropriate connections between these views? Responses of some students to questions about dice even indicate that after collecting empirical evidence in classroom exercises, students use this evidence to reinforce their personal views that particular numbers have greater chances than others. It may be that greater familiarity with hands-on data and how these are compiled in databases is fundamental to understanding the relevance of available data, rather than basing reasoning on individual counter-examples such as "my grandfather smoked and lived to 80, so it makes no difference if you smoke or not."

RISKY INFERENCES

Statistical literacy should also include awareness of statistical issues which permit critical questioning of the quality of the data on which risk statements are often based, and of claims of causal connections inferred from statistical associations. For the extract

shown in Figure 4, Grade 9 students (n = 339) experienced difficulty assessing the reliability of the biased sample described in the article, with 32% agreeing with the survey results because the sample was large or people were free to express their opinions. While 22% stated at least one objection to the sampling process, only 5% put together more than one idea based on the voluntary nature of the poll, the expected audience for the radio station, the timing of the survey, repeated calls, and such issues.

Decriminalise drug use: poll

SOME 96 percent of callers to youth radio station Triple J have said marijuana use should be decriminalised in Australia.
The phone-in listener poll, which closed yesterday, showed 9924 — out of the 10,000-plus callers — favoured decriminalisation, the station said.
Only 389 believed possession of the drug should remain a criminal offence.
Many callers stressed they did not smoke marijuana but still believed in decriminalising its use, a Triple J statement said. [...]

Figure 4. A newspaper extract (*The Mercury*, 26 September 1992, p.3).

Developing statistical literacy at this level may also help in motivating adolescents to gain a sense that they are not being manipulated by media authorities. Students should be aware that data may be collected or represented in ways to suit the author's desired conclusions. Critical evaluation of the extract shown in Figure 5 may encourage students to question the forced conclusion which has minimal support from the stated data.

Regrets on early sex

MOST women believe they should have waited longer before having sex, a survey has found.
The New Zealand survey of first sexual intercourse found that on average women were aged 16 at first intercourse and men were 17.
While 54 per cent of women thought that they should have waited longer before having sex, only 16 per cent of men felt the same way. [...]

Figure 5. A newspaper extract (H. Carter, *Herald Sun*, 2 January 1998, p.14).

CONCLUSION

Statistical literacy may be an important aspect of educating students about risk to make informed decisions. If risk-taking is motivating to some adolescents, it may be that students in mathematics classes can be encouraged to learn through game simulations of real-life situations with risks based on real-world data. Experiences with data collection

and handling may be important for students to develop an appreciation of the statistical foundations for risk statements, and critical evaluation skills to make informed decisions.

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REFERENCES

Australian Education Council. (1991). *A national statement on mathematics for Australian schools*. Carlton, Vic.: Curriculum Corporation.

Australian Education Council. (1994a). *A statement on health and physical education for Australian schools*. Carlton, Vic.: Curriculum Corporation.

Australian Education Council. (1994b). *A statement on science for Australian schools*. Carlton, Vic.: Curriculum Corporation.

Australian Education Council. (1994c). *Health and physical education - A curriculum profile for Australian schools*. Carlton, Vic.: Curriculum Corporation.

Australian Education Council. (1994d). *Mathematics - A curriculum profile for Australian schools*. Carlton, Vic.: Curriculum Corporation.

Kapadia, R. (1986). Didactical phenomenology of probability. In R. Davidson and J. Swift (Eds.), *The Proceedings of the Second International Conference on Teaching Statistics* (pp. 260-264). Victoria, B.C.: University of Victoria.

National Council of Teachers of Mathematics. (1989).*Curriculum and evaluation standards for school mathematics*, Reston, VA.

Walker, V. R. (1994). Probability, direct inference, and a conceptual gulf in risk communication. Paper presented at the Society for Risk Analysis 1994 Annual Meeting.

Watson, J. M. (1997). Assessing statistical literacy using the media. In I. Gal and J. B. Garfield (Eds.), *The Assessment Challenge in Statistics Education* (pp. 107-121). Amsterdam: IOS Press and The International Statistical Institute.

Watson, J. M., Collis, K. F., and Moritz, J. B. (1995). Children's understanding of luck. In B. Atweh and S. Flavel (Eds.), *Proceedings of the Eighteenth Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 550-556). Darwin, NT: Mathematics Education Research Group of Australasia.

Watson, J. M., Collis, K. F., and Moritz, J. B. (1997). The development of chance measurement. *Mathematics Education Research Journal, 9*, 60-82.