The Kama Sutra, Romeo and Juliet, and mathematics: Studying mathematics for pleasure

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The motivation of students is of great import to mathematics teachers. Such an abstract powerful language needs to be valued or students will not wish to study it. This paper argues that mathematics may be better appreciated through the beauty of the language in which problems are written, respect for the cultures of others and through relevance to our students' lives. Now what is more relevant to all of us than sex and romance?

While working at home I had heard Bill Barton, a professor of mathematics from Auckland University, discussing mathematics problems in the *Kama Sutra* on the radio with Robyn Williams. That really grabbed my attention. Part of the conversation went like this:

> Bill Barton: …mathematics was part of what everybody did and that it might be used as an activity that you did together for pleasure, is an interesting concept to know that there was a society or a group within a society that did this… (The Science Show 17 May 2003)

The only other part I heard said that the first chapter of the *Kama Sutra* contained mathematics problems. Hence I started searching for the *Kama Sutra* in bookshops — I was obsessed. However, looking through the first pages of a copy of the K*ama Sutra* I could not see any mathematics problems, all I could find was a long list of subjects to be studied along with the *Kama Sutra*. A few numbered points after the injunction to study languages and the vernacular, there it was:

> 62. Arithmetical recreations. (Burton, 2003)

You will notice it says "recreations" — the study of mathematics was not to be a chore.

Finally, I looked up the ABC website and the text of the interview I had only partly heard. Professor Barton and Robyn Williams were discussing one of the ways to entice students to study mathematics. The first chapter of the *Kama Sutra* had contained mathematics problems but, as the centuries passed, the first chapter had been removed. A visiting professor from India had some samples and had shown them to Professor Barton.

As Barton claims in the interview, they are beautifully and lasciviously written — with rather wonderful imagery. Here is one of them, from Joseph's (1992) *The Crest of the Peacock*, whose solution uses algebraic inversion:

> O beautiful maiden with beaming eyes, tell me, since you understand the method of inversion, what number multiplied by 3, then increased by three-quarters of the product, then divided by 7, then diminished by one-third of the result, then multiplied by itself, then diminished by 52, whose square root is then extracted before 8 is added and then divided by 10, gives the final result of 2? (Joseph, 1992, p. 274)

For the answer we start with the result (2) and proceed as follows. When the problem says divide by 10, you multiply; when told to add 8, you subtract 8, and so on until the original number is obtained:

$$\left((2)\,(10)-8\right)^2+52=196$$

$$\sqrt{196}=14$$

$$\frac{(14)\left(\dfrac{3}{2}\right)(7)\left(\dfrac{4}{7}\right)}{3}=28$$

Here is another:

> From a swarm of bees, a number equal to the square root of half the total number of bees flew out to the lotus flowers. Soon after, 8/9 of the total swarm went to the same place. A male bee enticed by the fragrance of the lotus flew into it. But when it was inside the night fell, the lotus closed and the bee was caught inside. To its buzz, its consort responded anxiously from outside. Oh my beloved! How many bees are there in the swarm? (Bhaskaracharya's Lilavati) (Joseph, 1992, p. 274)

As Joseph comments, Bhaskaracharya's approach is equivalent to solving the following equation:

$$\sqrt{\left(\frac{1}{2}\right)x}+\left(\frac{8}{9}\right)x+2=x$$

where x is the total number of bees in the swarm and it is presumed the male bee and his partner were late arrivals from the same swarm, hence the "2" in the equation above; $x = 72$ is given as a solution, however more than one solution is valid according to Bhaskaracharya (Joseph, 1992, p. 274).

Other cultures besides India's have their mathematical problems embedded in interesting, romantic stories.

What could be more romantic than *Romeo and Juliet*, and of interest to young people in their teens and early twenties? Cresswell (2003) has some mathematics for lovers. She relates the method Harvard lecturer Steven

Strogatz used to gain his young mathematics students' attention. I wish my mathematics teacher had used it!

The way Cresswell tells it, Strogatz translated a common undergraduate mathematics problem into language he thought his students would relate to: the evolution of the love affair between Romeo and Juliet. Here is the problem as he presented it to his students:

> Romeo is in love with Juliet, but in our version of the story, Juliet is a fickle lover. The more Romeo loves her, the more Juliet wants to run away and hide. But when Romeo gets discouraged and backs off, Juliet begins to find him strangely attractive. Romeo, on the other hand, tends to echo her: he warms up when she loves him, and grows cold when she hates him.
> (Cresswell, 2003, p. 2)

This is expressed mathematically in two equations as:

$$\frac{dR}{dt} = aJ, \ \frac{dJ}{dt} = -bR$$

where R is for Romeo's feelings and J is for Juliet's. It is at this point that Creswell could have been more explanatory — by showing the links between the equations and the feelings of the young lovers. Here is my attempt to explain the situation to students:

> $\frac{dR}{dt}$ and $\frac{dJ}{dt}$ are rates of change in Romeo's and Juliet's feelings for each other with respect to time — if expressed in a graph they would be the gradients of the curves. As Romeo's ardour increases Juliet's feelings for him decrease, here expressed as a negative *-bR*; but when Romeo's attentions decrease, Juliet's feelings for him increase: *aJ*. Romeo simply mirrors Juliet's feelings for him: his feelings for her increase when she loves him and cool off when she hates him. The letters *a* and *b* are constants, meaning they do not change, or vary, when the lovers' feelings change. When Romeo's feelings are negative but create positive feelings in Juliet, this is mirrored in the mathematics: a double negative makes a positive. Puzzled? Do not give up; think about it!

But *Romeo and Juliet* is a story of requited love; what about unrequited love — a feeling many university undergraduates (and high school students) would have experienced?

Cresswell (2003) describes the story of two other lovers: Petrarch, the Italian poet, and Laura, a married woman. Petrarch's poems show his adoration for Laura, his despair over his unrequited love, his fantasies about their union, his impatience with her coolness, and his forgiveness of her negative feelings.

According to Cresswell (2003), an English psychologist, Frederic Jones, thought that Petrarch's poetry went in cycles and that these cycles mirrored the events of his romantic attraction to Laura. These being:

- Laura and Petrarch's responses to the other's appeal;
- the fading intensity of how they each feel for the other caused by lack of attention;

- how Petrarch's love for Laura sustains his poetic inspiration;
- how the more time Petrarch spends engrossed in his poetry the less time he spends indulging and therefore fostering his passionate obsession;
- the fact that Laura is a beautiful high-society lady who naturally attracts flirtations and that she quite likes Petrarch's attentions to a degree;
- Laura's sensitivity to Petrarch's advances;
- Laura's disdain for Petrarch should he place too much pressure on her: sometimes his poetry becomes quite intense, sometimes to her embarrassment it was sung in public;
- the subsiding of Laura's antagonistic feelings over time — after all, she is flattered by Petrarch's attentions;
- how Laura feels sorry for Petrarch when his poetry shows signs of too much desperation and therefore how she returns to flirting with him;
- the fact that, like most people, Petrarch loves to be loved and hates to be hated (Cresswell, 2003, p. 10).

Cresswell continues: Jones's results were subjective, but they could be checked with mathematics, and they were, by an Italian mathematician, Sergio Rinaldi. Professor Rinaldi thought that *differential equations* could express the development of the relationship and date the poems. Here are his equations:

$$\frac{dL}{dt} = \alpha_1 L + \beta_1 \left[P\left(1 - \left(\frac{P}{\gamma}\right)^2\right) + A_p \right]$$

$$\frac{dP}{dt} = -\alpha_2 P + \beta_2 L + \frac{\beta_2 A_L}{1 + \delta Z(t)}$$

$$\frac{dZ}{dt} = -\alpha_3 Z + \beta_3 P$$

These three equations reflect the mixture of Laura's interest, Petrarch's passion, and his poetic creativity — being one equation each for the influences on his poetry. Since these equations measure rates of change over time they are part of calculus.

Some students may be intimidated by the equations describing Petrarch and Laura's romance. However, they are not as difficult as they seem. The information following may assist students. Please note it is written for students, not teachers.

So, for the "Petrarch and Laura" equations:

$\frac{dL}{dt}$ are the changes in Laura's feeling over time, $\frac{dP}{dt}$ Petrarch's feelings over time, and $\frac{dZ}{dt}$ is the cyclical pattern found repeated in Petrarch's Canzoniere over the years. The Greek letters: alpha α, beta β, gamma γ and sigma δ stand for constants, numbers that do not change (as opposed to variables that do). The subscript 1, 2 and 3 after the minus alpha and beta merely differentiate between the constants alpha and beta, in the three equations. For example, in the second equation $\beta_2 L$ represents the fact that Petrarch "loves to be loved and hates to be hated". A_p in the first equation represents the attentions

Petrarch pays to Laura, and A_L in the second equation the attentions Laura returns, or does not, as the case may be. Parentheses just show which part of the equations you should calculate first.

The Middle East is always in the news so here is a problem from that part of the world to interest your students, from Cresswell (2003).

In a kingdom a sultan starts to question the intelligence of his chief adviser. Knowing the adviser is looking for a wife, the sultan arranges for one hundred intelligent and beautiful women to be brought before him in succession. The adviser's task is to choose the woman with the largest dowry. If he picks correctly he can marry the woman and keep his position. If not, he will die.

The women present themselves to him one at a time and tell him their dowry. Each time he must decide immediately if that woman has the highest dowry out of the one hundred, or he must let her go. The adviser has no idea of the range of dowries before he starts and cannot return to any woman he rejects. Once he does reject her however, that is it. The adviser begins to wonder if having a wife will be worth it but it is too late: the sultan has spoken and his word is law. Is there anything he can do to increase his chance of picking the woman with the highest dowry and thereby keep his head on his shoulders? (Cresswell, 2003, paraphrased)

Mathematics has the answer Cresswell (2003, p. 44) states: two pages of equations like this one and he will know:

$$pi(s,n) = \frac{1}{n}\sum_{k=s}^{n}\frac{s-1}{k-1}$$

Why not challenge your students to produce at least some of the equations? (The answer is in Cresswell's book, page 44, or see the Appendix.) The story is wonderful but so is the power of mathematics.

Although the sexual drive is an important part of all of us, male and female, Barton states that student response to the problems from the Kama Sutra is mixed: there are some students who respond and some who are left cold. Perhaps the answer to motivating students, apart from taking an interest in, and problems from, the many different cultures from which our students come, lies in Barton's reply to Williams' query about turning people onto mathematics. Thus: "the answer… is actually just to bring the enjoyment that mathematics brings to me out into the classroom and let people see it" (The Science Show, 2003). This is good advice for all teachers, so if you wish to learn more about the history of mathematics in non-Western countries and "jazz up" your mathematics teaching, Joseph's (1992) and Cresswell's (2003) books are both useful and fascinating!

References

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Joseph, G. G. (1992). *The Crest of the Peacock: Non-European Roots of Mathematics.* Ringwood: Penguin.

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http://www.abc.net.au/rn/science/ss/stories/s848898.htm, accessed 28 February 2004.

Appendix

Answer

This is what the sums suggest he must do, Cresswell continues: he should check and reject the first 37 women, but make a note of the highest dowry in that group. Then starting with the thirty-eighth woman he should pick the first woman he meets whose dowry is higher than the highest dowry from the first group. This is how to maximise his chances. Now there is a possibility he might have already rejected the woman with the highest dowry from the first group of thirty-seven women, or he might pick a woman too soon. But the method described is his best option and he has a 37 percent chance of success. It may not seem good enough but it is a whole lot better than his chances if he just guessed — a mere one percent (Cresswell, 2003, p. 44).