The Maths and Computing Magic Show

The history of using mystery

The British Science Festival in Newcastle this year saw Matt Parker, with assistance from Peter McOwan, again perform their popular Maths and Computing Magic Show. The show has proved something of a hit with festival goers over the past few years combining a magic show, and a glimpse behind the curtain to see the maths and computing ideas that power the tricks. Card magic and conjuring tricks have proved popular and effective methods to open the door to maths. They have been used in engaging students with mathematical concepts for many years, and the current popularity of UK television shows focusing on street magic and high profile celebrity magicians such as David Blaine, Dynamo and Derren Brown has given this particular approach a new and enhanced awareness with the public. In this article we explore the history of mathematical magic, the fascinating stories of some of the main practitioners of the art and some useful tips for those who wish to try it for themselves.

Though arguably the first recorded magic trick, the cups and balls trick illustrated on the walls of an Egyptian tomb, was accomplished by sleight of hand, magic tricks with a mathematical basis have a long history. The exquisite mechanical complexity of the magical automata of Heron of Alexandria, an ancient Greek mathematician and engineer required practical, scientific and mathematical skills in their creation. His books *Pneumatics* and *Automata*, for example, describe a system that magically opens temple doors when alter fires are lit and a metal horse (see Figures 1 and 2) that can keep drinking as a sword passes through its neck. For an animation showing how the magic horse of Heron works see www.kotsanas.com/gb/exh.php?exhibit=0301008

Back in Britain in 1584 Kent magistrate and gentleman Reginald Scott opened eyes and minds when he wrote his expose of medieval witchcraft entitled *The Discoverie of Witchcraft*, where-in the Lewde dealing of Witches and Witchmongers is notable detected. The book, held by many to be the first ever magic book to be published, included a section on techniques used to trick believers. It described a trick known as the grandmother’s necklace, where a clever bit of mathematical topology made it seem possible to magically pass rope through the middle bead from a string of three beads.

Since then tricks based on concealed mathematics have flourished, often as carnival scams. Pricking the garter, also later known in a somewhat modified form as fast and loose, required victims of the scam to select which loop in a rolled belt or chain would hold fast when the belt was pulled away. This scam became so notorious that it was mentioned by Shakespeare and came into common usage in the phrase ‘playing fast and loose with your money’. The scam was popular in World War II and was known as the old army game. It still managed to part the punters from their money’. The scam was popular in World War II and was known as fast and loose, required victims of the scam to select which loop in a rolled belt or chain would hold fast when the belt was pulled away. This scam became so notorious that it was mentioned by Shakespeare and came into common usage in the phrase ‘playing fast and loose with your money’. The scam was popular in World War II and was known as the old army game. It still managed to part the punters from their cash even though versions had been in existence since the renaissance, such can be the power of mathematical magic.

In more recent times the term mathemagician has entered common use. These skilled performers, frequently practicing academic mathematicians with a passion for doing magic, use maths based magic effects to both entertain and to enhance deeper learning and engagement with a range of mathematical sciences. Perhaps the most influential mathemagician of recent time is the late Martin Gardner. Gardener’s books and *Scientific American* articles are frequently cited as being the inspiration that started many on their interest in maths as well as maths magic, and the interested reader may wish to start their exploration of the subject with these publications.

The applications of magical effects as a gateway to deeper learning of mathematical concepts range from computer science fundamentals, to number theory, discrete maths and even fractals and Fermat’s last theorem. For teaching statistics and probability, magic can provide an ideal and engaging point of entry for initiating classroom study. There are a number of seemingly magical effects, for example based round the exploration of apparent tests of ESP or seemingly cheating in gambling, which rely on statistical principles to operate. In a recent paper, Lesser and Pearl [1] identified magic as one of the 20 modalities of fun identified for motivating students learning statistics.

There are in the field of educational mathematical magic several high profile celebrities with fascinating stories. Perhaps the most famous and certainly the one with the most inspirational life story is Professor Persi Diaconis. A talented mathematician in school, Diaconis left home and formal education at 14 to tour with the famous sleight of hand magician Dai Vernon. During his time as a professional magician he became interested in the scams used by crooked gamblers, and developed an increasing interest in statistics and probability. He returned to school to pursue his love of maths, graduated, and went on to complete a PhD in Mathematical

![Figure 1: Diagram of the magic horse. Courtesy of Museum of the Ancient Greek Technology Kostas Kotsanas, www.kotsanas.com](image1)

![Figure 2: Model of the magic horse. Courtesy of Museum of the Ancient Greek Technology Kostas Kotsanas, www.kotsanas.com](image2)
Statistics from Harvard University in 1974. He is currently the Mary V. Sunseri Professor of statistics and mathematics at Stanford University and has published extensively in the mathematical literature on areas including randomness and probability and is a significant academic presence in the field.

His recent book, *Magical Mathematics: The Mathematical Ideas that Animate Great Magic Tricks* [2], is co-authored with Ron Graham. Graham is also a professor of mathematics and computer science at the University of California at San Diego, and once worked as a professional juggler and trampoline acrobat. In the book they present magic tricks to perform and detail their links to deep mathematical concepts. The book usefully also contains a fascinating history of mathematical magic and the characters who have contributed to this field of performance.

Self-working card tricks are perhaps the most commonly used as the basis of mathematical magic, but using magic to teach mathematics is not limited to them. Arthur Benjamin has achieved an international reputation in another field of magic; lightening mental calculations. This ‘super human power’ type of act was popularised by music hall magicians in the past, and still remain a popular element of many professional magicians’ shows today. Benjamin himself has performed at both the Magic Circle in London and the Magic Castle in California, testament to his profile as a professional magic practitioner. Like Diaconis, Benjamin has strong academic credentials, holding a Bachelor of Science in Applied Mathematics from Carnegie Mellon University, a Master of Science in Engineering in Mathematical Sciences in 1985 and PhD in Mathematics from Johns Hopkins University, and has published in the field of combinatorics. He currently works as a Professor of Mathematics at Harvey Mudd College in California. Another popular and high profile mathematician/magician is Colm Mulcahy of Spelman College, Atlanta, who has just published a fascinating book called *Mathematical Card Magic* [3] and hosts a great online resource at http://cardcolm-maa.blogspot.co.uk/

An early pioneer of using magic principles in computer science is Dr Brent Morris, whose PhD work on the mathematical properties of the perfect (Faro) shuffle led to a patent for a high speed dynamic computer memory, both of which were based on inspirations taken from his interest in magic. This approach can extend beyond shuffling, using a deck of cards to represent a set of computer data, and drawing a direct analogy between the self-working card trick mechanics and a computer algorithm.

We have been using mathematical magic as part of the public engagement strand of our research project, CHI+MED concerning the development of safer medical devices [4]. We wanted a way to introduce students to the mathematical concepts behind the complex analysis approaches we are using to explore the safety of different designs of medical devices (see Figure 4).
Mathematical magic provided a perfect vehicle. Card tricks are a fun way to introduce ideas of mathematical modelling, proof and formal specification and the verification of computer algorithms. The motivation for verification arises in the context of a magical performance, because of not wanting a trick to go wrong in front of a live audience. You need to be sure the underlying algorithm always works: and mathematics can be used to verify that. This carries over easily into discussions of safety critical software systems and testing mathematically for bugs in computer software. This approach to raise awareness of software verification through easy to learn tricks also allows discussion about human factors in computing, another aspect of CHI+MED. In direct analogy to the presentational element of a trick where needing to understand the magic requires the reader to pass a threshold of necessary engagement, to understand the trick needs an engaged to want to dig deeper to discuss and understand, rather than feel unduly tricked or deceived.’ But employed correctly those moments of wonder stick in the mind, engage the emotions and promote learning. After all we all love a mystery to solve.

The continuing impetus to find new ways to engage pupils and the public as to the fundamental importance and wonder of mathematics, the key principles behind our magic show at the British Science Festival, shows there is utility in employing magic as a gateway to discovery. There is now a new generation of maths teachers using maths magic as a way to pull in their pupils with a minimum of props, to catch their attention and generate a sense of wonder, give them transferable skills to entertain their friends and most importantly to facilitate a way to start exploring the underlying fundamental mathematical concepts. And that’s quite a neat trick!

Further Information
There are videos and free book downloads at www.cs4fn.org/magic and www.mathematicalmagic.com. iTunesU at Queen Mary also includes the specially commissioned Magic at Mile End series of films, featuring Brent Morris, Art Benjamin and Colm Mulcahy, in specially filmed performances of their acts and discussing their mathematics. We also recommend [6–11].

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REFERENCES