Passion Plays: Melodramas about Mathematics

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Abstract. Most people don't know that Michael Fellows' efforts to introduce mathematics to the public went beyond *Computer Science Unplugged* and engaged a bold, new venue — inventive, inquisitive theatre. He wrote several plays, but this chapter will only give a brief description of the *Four Cowboy Melodramas of Mathematics*. The term "melodrama" refers to a dramatic work that exaggerates plot and characters in order to appeal to the emotions. Each play proves at least one mathematical theorem. The dramas have been played on stage only a few times.

1 Introduction

Mike began to consider how best to communicate the metaphors of mathematics through theatre. In notes about mathematics and theatre, Mike wrote, "What is mathematical science really all about? I believe it is about the unfolding of our collective abstract cognitive abilities, as part of our natural instinct to develop rich and expressive, as well as useful language. Mathematical science is therefore destined for the theatre, as it is powerfully and inherently metaphorical."[1]

In a 39 page unpublished manifesto on mathematical communication written about 1995, Mike described the potential of mathematical theatre for exploring the "cultural politics of curiosity" and "new cultural energies circulating in the world of mathematical science," particularly attracting and engaging the intellectual interests of wider audiences. Mike began to experiment with how to communicate sophisticated technical information on stage. He thought of this as "content-driven" theatre.

In 1997, Mike was awarded a fellowship to the Centre for Studies in Religion and Society at the University of Victoria. It was the first given to anyone in computer science. The title of his application was *Religious Imagery, Mathematical Metaphor and Popular Participation in Science: An Exploration of Passion Plays*. His abstract points out that "The use of mathematical metaphor in religious contexts is striking and has a long and important history, including perhaps the roots of the dominant modern scientific world view (that the intellect is superior to the senses in discerning timeless truths) in the Pythagorean religion of mathematics".

[1] In addition to the original play scripts and transparencies, I have had access to Mike's hand-written notes and papers to use for this chapter.

H.L. Bodlaender et al. (Eds.): Fellows Festschrift, LNCS 7370, pp. 80–87, 2012.

2 The Four Melodramas

Mike wrote four cowboy melodramas (think virtue tied to the railroad track by mustached villain). At a superficial level, the plays are almost vaudeville. They may be considered satires on standardized aspects of the school system. At a more serious level, they address issues in the politics of curiosity and are expected to be provocative. Each play dramatizes deep mathematics that has been part of Mike's professional research. Mathematics is feared by most people. Mike understood that putting mathematics on stage in any form would challenge the audience. He hoped to expose mathematics as a source of beauty, surprise and humility, and of fresh metaphorical insight into problems of every possible kind. He wrote:

> Mathematics is at the heart of the scientific and technological Mega-Machine that we have created. Part of our task is to own this Machine, joyfully and not in terror. We must come to grips with issues such as expressed by Gödel in interpreting his own beautiful theorem:
> "Either Mathematics is more than Man, or Man is more than a Machine."

Todd Wareham suggested that the Cowboy Melodramas belonged to the genre of "passion plays," in the sense of A. C. Cawley. Cawley described the primary concern of the medieval playwright as instruction to the audience through dramatic entertainment on the stage. Medieval morality stories were imbued with the folk-tale in order to include comic and human popular influences. Mike's love of literature and Heraclitus sense of culture shows free reign in the creation of poetic, fantastic and folk-tale elements in the plays.

The moralities in Mike's plays revolve around the ownership of science, and the opportunities for participation. Indifference of science professionals, and the tendency to treat knowledge as a 'secret', have contributed to the widespread alienation of the public from science. Mathematical science, which is the engine of modern life, which is more a culture of questions than answers, which consists of childlike curiosity, has been kept hidden from children.

3 *The Helen Keller of Arithmetic Story*

The first play is called *The Helen Keller of Arithmetic Story.* The second play is titled *Dragons.* Together they make a volume called *Visions of Joanna, A Cowgirl at the Edge of the Millennium.* (Helen Keller was an American author, political activist, and lecturer. She was the first deaf-blind person to earn a Bachelor of Arts degree.)

The mathematical theme of the *Helen Keller of Arithmetic Story* is the well-quasi-ordering of finite trees and Kruskal's Theorem. The Peano Arithmetic independent miniaturization and its associated fast-growing function plays a role in the showdown scene. Other topics making brief appearances inlude sorting networks, partial orders and Goldbach's conjecture.

The satire in the *Helen Keller of Arithmetic Story* is evident in the following description by University of Victoria, Canada Professor Maarten van Emden, from his 1998 diary.

> The play only makes its appearance after an enactment of a summary of Fellows' personal experiences in being exposed to the conventional wisdom in Education Land. Choice snippets: Piaget having proved that children only become ready for Infinity at the age of 15 and a half, the experiences of Joanna, age 7 are shown to contradict this. The games Joanna thinks up include tying a rope to a table leg and producing single waves at a time, then standing waves. She plays a game with her dog in which perverts like computer scientists recognize a formal grammar.
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> Just as lecturers are advised to start with a transparency giving an outline, Fellows tells about a play being planned, gives the outline on a transparency in the traditional professorial style and starts explaining how the play goes, whereupon the play, well, goes. In between scenes he goes back to the colourful, clever transparencies, which were created by Lisa Whittle. The transparencies and a bit of costume help Mike, in these one-man shows, change quickly from one character to another.
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> An early scene relates the traumatic experience of two children. While they are in the charge of the resident clown of the shopping Mall, their parents are swallowed by the Mall. This is illustrated by a transparency showing a monstrous Mall. Overlays show exclamatory clouds in the vein of: "23% off, 312 days warranty!" against "18% off, 777 days warranty!!!" Obviously, Math is important. As a result, the children go blind and deaf to arithmetic.

In the story, an old hermit (a transparency of Erdös in cowboy garb), visits the orphan children who have tragically become blind and deaf to arithmetic. He describes the notion of topological embeddings of trees, of one tree including another inside of itself, with the same root, and instructs the children that they have "the job of growing until your personal tree has grown big enough and rich enough in structural form to include all the trees that you have loved and tragically lost...until those lost trees that you have loved, live again inside of you."

The Good Cowboy demands that the standardized math exam be offered in Braille. All the children pass. The widow's lands are saved, and the villain is booed.

In 1999, Geri Lorway and I helped Mike present *Helen Keller* to 400 teachers at the California Mathematics Teachers Association at Asilomar. Mike constructed a special sorting network by putting thick cord under the tape that defined the network (the Sorting Network is described in the chapter on Computer Science Unplugged). Teachers pretended to be the blind and deaf children, and we had them take off their shoes, close their eyes, and with their toes feel their way

along the network. Geri remembers being impressed that Mike spontaneously asked if anyone played piano, finding a volunteer and then just asking her to do some cowboy music at his cue.

After the presentation, several teachers came up to Mike crying. They were quite emotional, saying that the plays reached their deep inner feelings, confusions and brought back memories of early school days. The emotive power of the plays was very high, and likely was related to the Paranoid Theory (described in Section 3 of the chapter on *Computer Science Unplugged*).

Geri Lorway writes about the plays:

> I believe it is a critical part of the whole that is not just Mike, but his work and the thing that is mathematics, the sciences and CS..... there is something so important in the deep emotional and if I can say spiritual impact that the idea of the passion plays brings to understanding why things like *CS Unplugged* are such phenomenal works.... the opportunity to bring the whole into one's understanding of learning, thinking, being human.
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> We must stop being such snobs about the *entireness* that feeds into genius.... the creative spirit is so intense it has to be allowed free reign and that is what those plays were.... they made some people catch their breath and say: My god there is way more to what I thought was the most horrible thing ever imagined: "mathematics"....

4 *Dragons*

The second play in the *Visions of Joanna* series is called *Dragons*. The satire is darker, and begins with parents being burned at the stake. They had been subversively pleading for "thinking skills." Their daughter runs into the forest. She returns disguised as a baby dragon, to lead a children's education revolution.

The mathematics is a dream-story centered on the Circular Braid Theorem (CBT). Props for the CBT are three tangled pieces of heavy, large-diameter ship-mooring rope, colored red, green and blue, which a shepherd dumps from his duffel bag, signifying the confusions of his village. The green rope symbolizes the work of the villagers in the fields. The blue symbolizes their collective community, and the red rope symbolizes terrifying dragons of which everyone lives in fear. The story of the shephard's vision (and the proof of the CBT) begins with a "lightning flash" staged by a camera bulb, together with yellow construction tape that flutters down from above the stage onto the tangle of ropes, with the initial tangle being the Boromean rings.

In addition to the proof of the CBT, mathematical content includes cameos about fractals and cryptographic one-way constructions to create computationally hard puzzles with which to paralyze the dragons.

The CBT proof involves marking positive and negative crossings of the yellow construction ribbon (the path of illumination) and each of the colored ropes.

To illustrate this, the shepherd describes wandering the hills as a young man, following old paths of confusion (a metaphor for the school system). He kneels down as if studying a large map, and makes a walking figure with his fingers that walks along the green rope, musing "The path of fields and work: day and night, day and night (As he talks, he marks with pieces of silver tape the positive and negative crossings of the green rope with the yellow ribbon)...and remembering each encounter with the vision.

He continues on the blue rope. "Remembering each time the path of our people met the illumination. The pride, the shame, the pride, the shame." (Now marking the positive and negative crossings of the blue rope with the yellow ribbon).

He does the same with the red rope path of the dragons. "What are these dragons? How do they live? The burning curiosity, the fear, the curiosity, the fear...!

In the next step of the proof, the shepherd takes a long thin multicoloured cord from his bag, and uses it to weave over and under through the tangle according to the markings. As he weaves, the shepherd uses the words "over" and "under" to describe the possibility of a life that has overcome the confusion in the village.

> "I imagined a life that would follow the path of the illumination, yet a life not just knowing what is, uncaring -- but a life of value! Under the shame, and over the pride, under the darkness, and over the light, under the fear, and over the curiosity...
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> "A life that could separate the bright from the dark. A spirit that could soar above in the brightness, and delve deeply to rest in the darkness....
>
> "A life that could separate the pride from the shame. A spirit that could reach beneath the shames and know them, and overcome the shallow prides....
>
> "A life that could separate the fear from the curiosity. A spirit that could reach down beneath the fears to touch their shivering roots, and reach above the curiosities towards enlightenment....
>
> "And then I reached out my hand to see where that life, if I chose to live it, would take me..."

While speaking, the shepherd has been putting his hand along the multicoloured path, over and under the big ropes and creating the circular braid. The story and the proof reach a crescendo, with mathematics (the CBT) empowering a new way of seeing reality.

"And this is what I have found! Do you see how the circles of our lives and work in the fields - our peoples - and the dragons - are all woven in hidden parallels together in the same circle of being - do you see? This is our life. There is no confusion."

There are other mathematical elements in *Dragons*, such as graph three–coloring, enacted during a children's revolution with colors indicated by body positions: arms raised overhead, arms stretched out from the sides, squatting. As with all the plays, Mike is the only actor.

4.1 *Bob, Cowboy Mathematician of the Yukon*

In the third play, *Bob, Cowboy Mathematician of the Yukon*, Mike used Parameterized Complexity and religion to address big issues of ownership and participation in mathematics. The first scene shows Cowboy Bob explaining computational complexity to interested children in a local school. Towns-people are horrified when they become aware of Bob's religious metaphor, that parameterized complexity "exploits thin zones of parametric viability" – small ranges of parameters, for which we can work out a "deal with the Devil." They begin to mumble, "Devil-worshipper." When Bob makes an isomorphic relation to biological life, which also inhabits a largely hostile universe, the towns-people become increasingly intolerant (think of America's "evolution vs creationism" controversy). A third interlocking theme becomes the gradual accretion of layers of understanding and meaning, the stories we attach to the rock of fact. Bob calls this "The Talmud of Story Science."

The meanings that various people have of mathematics come out when they answer Cowboy Bob's question, "Would Space Aliens have the same theorems we do?" (This question was raised in one of Mike's classes at UVIC. By "Space Aliens" is meant beings with enough mathematical sophistication to design and fly spacecraft through the universe. Mike was taken aback that there were a variety of answers – even when the question was rephrased to be more specific, "Would Space Aliens have the same theorems about the prime numbers?" He began to carry the question around to scientific colleagues, who also had a variety of answers.)

The last scene finds Cowboy Bob in a saloon talking to his son. "Each of us is a computational creature, faced with the fundamental problem of being finite. The most important parameter of all is the individual." Bob concludes that when the Space Aliens arrive, they are going to want to talk to scientists, the people who are "interested in the Devil". A crowd has gathered outside. They are shouting: "Den of iniquity! Send out the devil worshipper!" The hymn Onward Christian Soldiers is heard.

Bob, Cowboy Mathematician of the Yukon, and the two plays in *Visions of Joanna, A Cowgirl at the Edge of the Millennium*, were a response to what Mike saw as a school math curriculum that had been stripped down to, as Mike put it, "18th century shopkeeper arithmetic – grocery arithmetic." He pointed out that while there is nothing wrong with arithmetic, mathematics is much, much more — the essential engine of modern science. Teaching such a narrow view of mathematics is a tragedy and a crime against children.

4.2 *Wagon Train to Infinity*

The final melodrama, *Wagon Train to Infinity,* is the only one of the four plays that is not a satire on schools. This play focuses on what it means to be a spiritual individual in modern science and society. One might say that Mike's personal moral imperative is compassion and a creative attitude toward life. Sometimes Mike says, "There is a lot to be said about Attitude."

Wagon Train to Infinity stars the Lovasz Local Lemma, some appearances of Kestens Theorem on percolation in the plane, and results on graphical evolution. The wagon train is going to Infinity, which represents mathematical literacy for everyone (It's like Oregon, with lands that go on and on and on). The reason for going is that it is fun there. It gives a useful perspective. Because we get the odd bit of comfort there. Because it is a fair place. Along the way, the Wagon Train is attacked by the Intuits (e.g., fundamentalists).

A Wagon Train is not just about where one is going, but what one is leaving behind. In this story, they are leaving behind artists ignorant of mathematics, cultures with no curiosity, and teachers who give you a "C" because they don't like your opinions.

The Preacher character equates Infinity with the New Testament, and a yearning to "get beyond the finite numbers" on the way. The finite numbers to go beyond are those of modern atrocities, such as the number of deaths in Argentina, or the number of minutes before unconsciousness from electroshock torture. These are all intoned as if from the *Book of Numbers*, in Old Testament style. The Preacher's sermons correspond to basic theorems about Cantor diagonalization, and he enacts the ghost dance of the uncountable.

4.3 Diagonalization

The notion of diagonalization is a powerful metaphor for Mike. In a festschrift chapter in honor of the humanistic mathematics educator Stephen I. Brown, Mike used diagonalization to describe Christianity (partly as a means of describing Steve's work). Each person who accepted the Invitation to take up their (individual) cross and follow, contributed to the power of the invitation. In the extended metaphor, each person was a "row" and the Invitation the diagonal. Moving beyond ancient religious human sacrifice cults, the metaphor witnesses a new kind of civilization formed when a creative response comes from each individual. All the individual sacrifices became embodied in the "new" sacrifice. Each individual human being is a creative collaborator with God.

Mike has even used diagonalization as a metaphor for his favourite sport, *surfing*! In surfing, the analogue of one of Cantor's rows is: "heading directly into the beach." Instead of taking that ride, diagonalizing "tweaks" it, and we move a bit sideways. Now from our new spot we could still go directly to the shore. We don't take that one either. We go on a diagonal. We enjoy going on a diagonal to explore the complexities of real currents.

The steadfast confidence that Michael Fellows has in human curiosity, and his sense of justice that the natural curiosity of children not be impeded or thwarted, drive his plays forward. His belief that mathematics is a metaphor on multiple layers makes his theater relevant to everyone in all phases of their lives.[2]

References

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3. Cawley, A.C. (ed.): Everyman and Medieval Miracle Plays. Introduction by J.M. Dent 1974, Everyman 1956, Orion Publishing group, Orion House 5, Upper St. Martin's Lane, London WC2H 9EA, ISBN 046087280X

[2] On a personal note, although Mike and I had corresponded about mathematics popularization activities, we had not met until he invited me to come up from San Diego to see the plays. They were being presented at the 1998 Fringe Theatre Festival in Victoria, Canada. By the end of that weekend, we had decided to get married.

We have enjoyed the visits of many researchers to our home in Australia. Quite often, Mike receives an email saying something like, "You don't know me, but I have become interested in Parameterized Complexity, and I have this question..." Mike's response is to arrange for the person to come visit, and to set up the flip-charts. We have a couple of traditions, in addition to sharing *Unplugged*, the plays, and "Mr. Opinion" (*The Guide to Modern World Literature*, a reference book by Martin Seymour-Smith.) One is for students to cook a meal from their native country, and this has resulted in charming phone calls home asking Mom for recipes and instructions. Another is teaching the visitor to surf – but we haven't asked them to diagonalize! Yet, many do so naturally.