Educational Drama (EduRama): An innovative Pedagogical Model for Enhancing Learners’ Interest in Mathematics

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ABSTRACT
In this paper we explore how educational drama (EduRama) can be used to enhance learners’ interest in mathematics. ‘Arcadia’ a play by Tom Stoppard, and ‘Fermat’s Last Tango’ a musical by Joanne Sydney Lessner, are taken as examples of creative works that have been recognized for their ability to introduce mathematical concepts. The main thesis of this paper is that we can enhance the interest of learners in mathematics by introducing mathematical concepts through drama and other creative works. One such EduRama, ‘To Log or Not-to-Log’, is included to demonstrate the concepts underpinning this innovative pedagogical model.

INTRODUCTION
Mathematics has always been a challenging field of study; traditionally the best brains of any era have studied and advanced it. However in recent times, with greater number of people getting access to higher education, it has become mandatory for most to understand the fundamentals of mathematics; and more advanced topics in mathematics are required by those taking up the study of Science, Technology, Engineering and Mathematics (STEM). Traditional pedagogy comprising lectures and tutorials has been rather alienating for many students of mathematics. The need for making mathematics an interesting and engaging field for the majority of learners is the motivation for exploring drama as a new pedagogical model.

We begin by investigating two creative works recognized for their mathematical content (there have been many more such works including movies, TV serials, and novels). First we explore the efficacy of a play, namely ‘Arcadia’ by Tom Stoppard [1] in generating interest in mathematical concepts such as Entropy and Chaos Theory.

Next we investigate a musical, namely ‘Fermat’s Last Tango’ by Joanne Sydney Lessner in bringing to life the struggle of a modern mathematical maestro Andrew Wiles in the 1990s, to prove Fermat’s Last Theorem [2]. This theorem (also known as Fermat's conjecture) states that no three positive integers a, b, and c can satisfy the equation $a^n + b^n = c^n$ for any integer value of n greater than two. It was made popular by the French mathematician Pierre de Fermat in 1637, by making a tantalizing statement that he had a proof for it, but the margin of the book he was annotating was not big enough to pen it down.

The main thesis of this paper is that we can enhance learners’ interest in mathematics by introducing mathematical concepts through educational drama (EduRama). One such EduRama (written by the author of this paper), namely: ‘To Log or Not-to-Log’, is included here to demonstrate the concepts underpinning this innovative pedagogical model.
ARCADIA

Arcadia, the play by Tom Stoppard [1], and the musical ‘Fermat’s Last Tango’ by Joanne Sydney Lessner [7], have been well recognized for their ability to arouse interest in the mathematical concepts introduced in these.

Vees-Gulani, in her analysis of the Arcadia, investigates its ability to link different areas often considered exclusive of each other [3]. She writes, “Tom Stoppard explores a variety of ideas and themes along different time lines, ranging from history and chaos theory to gardening and sex”. However she expounds, “Despite this range, the play does not strike the audience as a clutter of unconnected parts. Rather, Stoppard succeeds in unifying the play with an all-inclusive structure”. Thus, the play strikes an accord with the audience, as it can maintain narrative unity, despite the diversity of the themes it encompasses. This supports our conjecture that we can introduce mathematical concepts in a play and still have a compelling narrative that keeps the audience engrossed.

Antor credits Tom Stoppard in linking art and science in Arcadia [4], stating that Stoppard, “…discusses them in a way that links the arts and the sciences, thus bridging the gulf between the two cultures”. Implicitly Antor points to the fact that presently the arts and the sciences are considered exclusive fields. Often these fields reside in different departments or faculties, which rarely (if ever) interact with each other.

Arcadia has been prescribed as a text in many high schools. The following questions were posed to an arts student, who had studied Arcadia in her high school, around a decade ago. The questions, and the answers given by the student are as follows [5]:

Q1) Did the Arcadia play strike you as an ordinary play, or a play that was attempting to introduce some mathematical concepts?
A1) When I first read the play, my literature teacher alerted the class to the hidden mathematical ideas contained therein. Therefore it was a conscious reading of the scientific and mathematical ideas rather than just as a literary text.

Q2) Did you find any of the mathematical concepts hinder the narrative of the play in any way?
A2) For me the concepts added to the depth of the play and made it more than a story of a student and her teacher, it became a philosophical text. Much in the same way as many Greek philosophers wrote plays with scientific ideas in their works.

Q3) Did the play get you interested in any of the mathematical concepts introduced in the same?
A3) The notions of entropy and the butterfly effect became fascinating as I read the play.

Q4) Which aspect of the play made you keep reading it?
A4) I was thoroughly engaged in the narrative and also interested by their various dichotomies it explored. For example there was constant juxtaposition of classicism and romanticism in the description of the setting.

Q5) Did you further explore any of the mathematical concepts introduced in the play?
A5) Since reading the play I have not had further opportunity to look into the concepts.

Q6) Can you recall, and list, the mathematical concepts introduced in the play?
A6) ENTROPY...

In general, most current students’ interest in mathematics has been waning for the past few generations, particularly in Australia, due to a variety of reasons (further discussion on this issue beyond the scope of...
this paper). The above answers give some credence to the idea that drama can be used to arouse the learner’s interest in mathematical concepts; even for an arts student whose interest in mathematics had been ‘switched off’ due to a variety of reasons.

We can draw the following conclusions from the answers given by the student.

**Answer-1** indicates that because the teacher alerted the students to the fact that there were some mathematical concepts embedded in the play, the student was on the lookout for these.

**Answer-2** elucidates that the divorce between the arts and the sciences that has taken root in recent times has only been to the detriment of learning science. Greek (and Indian, and Chinese) philosophers of the past did not subscribe to this divorce. Thus, in the future, to enhance the joy of learning science (including mathematics) we need to orchestrate their remarriage.

**Answer-3** demonstrates that difficult concepts such as entropy and the butterfly effect aroused the student’s interest, particularly their application to real-life.

**Answer-4** shows that this student was not particularly interested in the mathematical concepts, she was more interested in “…constant juxtaposition of classicism and romanticism in the description of the setting” a statement that may be lost on most of the current STEM students.

**Answer-5** tells that this student did not devote any further time to learning mathematical concepts that she was introduced to through Arcadia. However, we hope that STEM students will take the time, and make some effort to go deeper in to the mathematical concept introduced in a play.

**Answer-6** reiterates that the concept of Entropy has stayed with this arts student even after a decade, despite the fact that she did not delve any further into its details.

**FERMAT'S LAST TANGO**

The struggle to find a proof to Fermat’s Last Theorem [2], which Princeton mathematician Andrew Wiles went through in the 1990s, was turned into a musical by Joanne Sydney Lessner, and called: ‘Fermat's Last Tango’ [6] [7].

In a review of this musical –along with that of other mathematical plays– Peterson states, “Although these plays, with their overtly mathematical themes and number-enthralled characters, have especially captivated mathematicians, they have also attracted remarkably diverse and enthusiastic audiences” [8]. Once again, we see that such creative works arouse the curiosity of non-mathematicians in mathematical concepts, when presented creatively.

Often we differentiate between our logical and emotional beings, even pointing to the fact that these are processed in the left and the right hemispheres of our brain respectively. By classifying people as left or right brained (as if the other half is missing), we have created a bigger chasm between the arts and the sciences.

In praise of the works such as the musical Fermat's Last Tango, Peterson says, “The scripts explore the counterpoint between pure logic and the emotional complexities of everyday life...” [8]. Thus, the need to build links between our logical and creative self is elucidated. This implies that to be a more holistic person we need to have better communication between the left and the right hemispheres of the brain. Building stronger linkages between the left and the right brain is one of the main motivations for using EduRama as an innovative pedagogical model.
EDUCATIONAL DRAMA – EDURAMA

Educational dramas (EduRamas) aim to enhance the learners’ interest in STEM topics, including mathematics. To achieve this, an EduRama needs to deliver various facets of science, technology, engineering and mathematics in a manner that these appear to be connected to the emotional self. This can be achieved by including various aspect real-life such as history, human struggle, joy, disappointment, love and sex. This will introduce the technical topics to the learners while they are enjoying drama reading, acting or listening. One should not try to explain the topic as in a lecture, but aim to garner interest in the topic and provide some metaphors that make the topic unforgettable.

The target group for these plays is senior secondary and junior tertiary students. The efficacy of drama as a teaching aid has been recognized by many authors [10] [11] [12] [13] [14]. In particular, its application to teaching English as a second language (ESL) has been investigated over the past decades.

However, as demonstrated by the following EduRama: ‘To Log or Not-to-Log’, even Mathematical concepts can be presented through drama. The purpose is to turn otherwise ‘dry’ content into ‘lively’ discourse.

To Log or Not-to-Log

CAST

1. Alpha Male Student
2. Beta Female Student
3. Gamma Male Student
4. Theta Female Student
5. Pi Either Male or Female

SETTING

A group of students at a Café / common room / class room.

PLAY

1. ALPHA: And I thought Uni would be fun.
2. BETA: Yes, this is worse than school. So many tests in just week four.
3. PI: W… why. Wha … wha …
4. THETA: Speak up sweetie. How will you get through the uni otherwise?
5. GAMMA: You gotta force your way through the bush, to get to the watering hole, mate!
6. PI: Don … don’t worry about me … about me. You guys are in trouble. You don’t even understand lo … lo… logs.
7. ALPHA: No worries here. I know everything about logs, and how to cut them fast.
8. THETA: Your axe is no good here man. You need not a fine blade, but a fine brain to get through these logs.
9. BETA: Guys, guys; let’s be serious. We got a test tomorrow. Mr. Maths is going to focus on logs, I bet.
10. PI:  How ... how do you know?
11. ALPHA:  'cos he said five times, "to pass this test you must be able to log into Maths."
12. GAMMA:  And when I asked, what did he mean by that, he grinned from one elephant ear to the other.
13. THETA:  I think that there is a Maths website that we should log into.
14. BETA:  I thought so too, and tried to find it on the Uni website till midnight. But, no cigar.
15. ALPHA:  You should have asked me, I can log into any website.
16. THETA:  No hacking!
17. GAMMA:  OK OK. Cool down. The only thing I see right now is a thick jungle of logs, like on the Kokoda Trail. And we have to push through like Aussie Diggers.
18. PI:  Why ... why do you always think of wars? I hate it!
19. ALPHA:  OK Dusting Hoffman, what do you know about logs?
20. PI:  No ... nothing. But I know about log ... arithms.
22. BETA:  OK. Here are some log ... arithms, Mr. Maths did in the class. What is the logarithm of a million to base ten?
23. PI:  Tha ... that's too easy. S ... s ... sex.
24. ALPHA:  Even I can remember that. Haaaa haaaa...
25. THETA:  No! He means six! He's half a Kiwi.
26. PI:  I ... said sss ... six.
27. GAMMA:  I got that. There are six zeros in a million; so the logarithm of a million to base 10 is six. But why? What the hell does logarithm mean?
28. ALPHA:  It's a bloody stupid word. We have had wooden logs for ever, but where does arithm come from? And what's it got to do with counting, I mean maths.
29. BETA:  Maths is more than just counting, according to Mr. Buddha ears. But why, and how, he never told us. "Go research it," he said. I hate it when he does that.
30. PI:  Maths is more than just numbers, it is a way of putting any concept in a ... in a ... formal language.
31. GAMMA:  Stop showing off Mr. Big Words. Show us, don't tell. Address the story question.
32. THETA:  Now you are showing off your story writing mumbo-jumbo.
33. PI:  Can you add.
34. ALPHA:  Yeh. We're not stupid.
35. PI:  Wah ... what is the opposite of add.
36. SETA:  Subtract. Even kids know that.
37. PI:  OK now tell me if I add three fives, what do I get?
38. BETA:  Fifteen, sweet heart.
39. PI:  We can write it as five plus five plus five. Right?
40. GAMMA: Ye ye. Move on. What's it got to do with logs?
41. PI: Be … be a bit patient. Or I am stopping right now.
42. THETA: Shut up yous all. Just listen to Aristotle.
43. PI: Algorizmi is more like it.
44. ALPHA: What? Who?
45. PI: Algorizmi. A Persian scholar who was born in 780 and died in 850. He translated the idea of decimal numbers -which were invented in India- into Arabic. The word algorithm comes from his name.
46. GAMMA: I prefer Al-Pachino. But go on Dustin Hoffman.
47. PI: OK. Five plus five plus five can be written as five times three.
48. ALPHA: Oh yeh! Even I understand that.
49. PI: What is opposite of times, or multiply?
50. BETA: Divide. Now don’t tell us fifteen divided by three is five. We know that.
51. PI: OK I won’t tell you. But can you tell me what is five times five, times five?
   ALPHA’s jaw drops. BETA counts on fingers. GAMMA takes out mobile phone to calculate. THETA grins.
52. THETA: One hundred and twenty five. Five times five is 25, and 25 times five is 125.
53. PI: Good. Now how can we write this, without writing five three times?
54. THETA: Five to the power three. By the way guys, I think of the base-number as a king sitting on his throne, and the power-number as the number of diamonds in his crown. And a bigger power-number, or more diamonds, makes him more powerful; with more soldiers in his court.
55. GAMMA: So five is the base-number, or the King’s size, sitting on his throne. And three is his power-number, diamonds in his crown.
56. BETA: That gives him one hundred and twenty five soldiers in his court.
57. PI: OK you’re getting there. So what is the opposite of power?
58. ALPHA: Weakness. None here mate!
59. THETA: Shut up. PI What do you mean by opposite of power?
60. PI: Like the opposite of add is subtract; opposite of times is divide; what is the opposite action of raising a base-number to a power-number.
61. GAMMA: I guess it is log. Am I right?
62. PI: Yes. Log is the o… o… opposite of power.
63. THETA: Yes, yes! Ten to the power six is a Million, or one followed by six zeros. That is why the logarithm of a million to the base ten is six. Yahoo.
64. ALPHA: But why call it log.
65. BETA: Might even call it anti-power.
66. GAMMA: That’s stupid.
67. PI: N ... not really. The opposite of log is called anti-log, so the opposite of power can 
be called anti-power. But it was called logarithm by its original inventor Napier 
around 1594. He joined two Greek words Logos, which means reason or ratio, 
and Arithmos, which means numbers.

68. THETA: Very impressive! Mr. Mega-Memory.

69. PI: OK now some tests. What is the Log of one thousand for base ten?

70. GAMMA: Guys let's picture this. The base-number, or the king’s size, is ten. He has one 
thousand soldiers in the court. What must be the power-number or the number 
of diamonds in his crown?

71. ALPHA: Three of course. So easy. Give me a tough one.

72. PI: OK, what is the log of 256 to the base two?

73. ALPHA: What is that?

74. BETA: This one I know, I know. Two to the power how much is 256? Don’t tell me. I know, I 
know. It’s eight. Right?

75. PI: Yes.

76. GAMMA: Now the king is of size two. So to have 256 soldiers he must have eight diamonds in 
his crown.

77. THETA: Fantastic! I can even kiss you Pi. Who says that you are irrational; you are the most 
rational one I know.

THE END

The main function of ‘To Log or Not-to-Log’ is to introduce (or reintroduce) the concept of 
logarithms. It can be read or played in a classroom, giving the opportunity for students to stand 
up in front of the class and have fun through acting, while learning about logarithms.

The metaphor of a crown is used in this play so that students can visualize logarithms 
beyond being an idea that can be written on paper (or computer screen).

As this EduRama has been written for Australian students, some Australian vernacular, 
history and elements of Australian student life have been used to garner interest.

FUTURE WORK

The author of this paper plans to write a collection of EduRamas suitable for first year 
engineering students. The topics for this collection will to be chosen by consulting STEM 
academics. Future research will involve testing the efficacy of these EduRamas in the classroom.

CONCLUSION

Drama-based learning can become a new pedagogical model with the potential to enhance 
students’ interest in mathematics. Creative works such as ‘Arcadia’ a play by Tom Stoppard, and 
‘Fermat’s Last Tango’ a musical by Joanne Sydney Lessner, have demonstrated their ability to introduce 
mathematical concepts to audiences, irrespective of the audience’s background. The EduRama given in 
this paper: ‘To Log or Not-to-Log,’ can be used to present the concept of logarithms to a first 
year university class, to learn about logarithms while having fun. It supports the main thesis of 
this paper that we can pique learners’ interest in mathematical topics if presented through drama.
REFERENCES


[5] Pallavi Sharda, Comments on Arcadia’s ability to generate interest in Mathematical concepts, email communication with Nalin Sharda, 9 March 2014.


