# CROSSING THE RIVER: TOWARDS AN EMERGING PEDAGOGY FOR INTEGRATING ARTS AND MATHEMATICS EDUCATION

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## Abstract

The recent trend towards integrating mathematics and arts education debunks the long-standing myth that regards mathematics as a cognitive thinking and rational left-brain activity, while the arts are considered to be an affective and emotional right-brain activity. Instead such integration serves to concretise the abstract concepts associated with mathematics education. It not only builds bridges between these hitherto dichotomous disciplines, but also brings a much more refreshing, enjoyable, yet creative quality to the teaching and learning of mathematics. Mathematics becomes much more comprehensible to those who would otherwise remain less inclined towards doing this subject. Using an interactive and embodies case study based on a story entitled, *Crossing the River*, this article provides an illustrative framework for an integrated approach to arts and mathematics education. The story demonstrates the assertion by Eric Jensen (1998) that there is no need to separate mind and emotions; for emotions, thinking and learning are all linked together.

**Keywords:** banking education, problem posing pedagogy, learning by doing, integrated approach, codification, the art of mathematics

## 1.0 Introduction

Traditional approaches to the teaching and learning of mathematics have had less impact on student learning because of a lack of a critical analysis of entry avenues in general and absence of creative activity in particular. To improve students understanding of mathematics, an arts integrated learning model has emerged which provides multiple ways of experiencing and expressing knowledge. As Mason, et al. (2005, p. 4) have argued, "the more maths teachers integrate arts into mathematics lessons, the more students gain on their maths tests". Students who are taught through arts integrated approaches tend to be more actively involved in the process of learning and tend to score higher at various levels of assessment, achievement and engagement (Kosky & Curits, 2008).

Using a series of arts based activities that were integrated into mathematics lessons with rural secondary school learners involved in a multidisciplinary community engagement project, this article seeks to reveal two contrasting approaches to mathematics teaching and learning. The first approach is based on 'bringing mathematics to learners', while the second one focuses on 'bringing learners to mathematics'. We argue that the former approach is inherently problematic and limited in scope since it assumes that the starting point for building mathematical understanding is the field of mathematics itself.

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The article seeks to argue for the adoption of an integrated learning approach that has artistic creativity as an entry point towards the learning of mathematics.

During the community engagement project in question, learners were made to participate in episodes based on a story entitled *Crossing the River*. Although the story itself appeared as if it was distanced from the discipline of mathematics, the integration of arts and mathematics enabled learners to come to a better understanding of the 'art of mathematics' as a creative learning activity.

## 2.0 The case for an integrated learning approach

To a large extent, the traditional education system has been characterized by what the popular Brazilian adult educator, Paulo Freire (1997) described as 'banking pedagogy'. In the banking system of education, the teacher 'deposits' knowledge into 'containers', in this case learners, who passively receive and store such knowledge for future recall, if not recital. In his own words, Freire argues that banking education:

> turns students into 'containers' or 'receptacles' to be 'filled' by the teacher. The more completely she fills the receptacles, the better a teacher she is. The more meekly the receptacles permit themselves to be filled, the better students they are (Freire, 1997, p.245).

By turning students into depositories, the 'depositor' of banking education fails to allow students much space for creativity and transformation. The scope of action allowed to students only extends as far as receiving, memorizing, filing and storing deposits of knowledge. For this reason, Freire (1997, p. 243) regards banking pedagogy as a form of 'narrative sickness' that treats reality as motionless, formulaic, compartmentalized and predictable. Freire explains that while a teacher teaches his/her students that, "Four times four equals sixteen …", and while students record, memorise and repeat such figures, they will not be able to perceive what four times four really means to their lived experience.

Banking education has also been widely discredited by several other scholars, most notably theorists from the critical pedagogy school. For instance, Ira Shor (1999) and Peter McLaren (2005) regard the role of the teacher in banking education as that of narrating information and asking questions that do not necessarily promote critical thinking. Such students may even resist their new role as active learners because of beliefs and misconceptions about what a student should be. They consider their role to be that of the teacher giving information which they write down what needs to be remembered and reproduced during exercises and tests. Ultimately, students see schooling as a game of rote memory instead of a space for learning in preparation for the real world.

Instead, Freire (1997) advocated for what he termed problem posing pedagogy that allows students to engage in critical thinking and the quest to become fully human. Problem posing education has the capacity to resolve the teacher-student contradiction that is inherent in banking education. The teacher discards the role of depositor, prescriber and domesticator, and becomes a humanist educator whose vocation is bound up with that of students' engagement in critical thinking, creativity, liberation and transformation. In Freire's view, in problem posing education:

> The teacher's thinking is authenticated (or validated) only by the authenticity of the students' thinking. The teacher cannot think for her students, nor can she impose her thoughts on them. Authentic thinking, or thinking that is concerned about reality, does not take place in ivory tower isolation, but only in (dialogic) communication (Freire, 1997, p. 247).

Problem posing education, as a form of dialogic pedagogy, is characterized by students as human beings, not passive automatons, engaged in posing, analysing and reflecting on problems relating to their world. By overcoming the dominance of banking education, Freire (1997, p. 249) asserts that problem posing pedagogy fulfils its function as the practice of freedom. In other words, the teacher exercises her authority on the side of freedom by enabling students to think, reflect and act upon their world. In fact, before Freire's seminal work on banking and problem posing education, the American educational philosopher, John Dewey (1938) had already posited that knowledge is created through the transformation of experience into cognitive concepts thereby causing individuals to change the way they think and behave. Education becomes the act of 'learning by doing', a process where knowledge is created by embodying and concretising experience. In his own words, Dewey (1938, p. 225) argues that, "… amid all uncertainties, there is one permanent frame of reference: namely the organic connection between education and personal experience." Like Freire's problem posing pedagogy, Dewey's model of experiential learning consists of a logical sequence that involves perceiving a problem, articulating the problem, finding a solution through acting on the problem, and finally reflecting on the problem. Dewey believed that the meaning of a given experience emerges as a result of the interaction between what the learner brings to the situation, or what the learner already knows, and what happens in determining the quality of the experience. In other words, the learner makes connections between his/her concrete experience and the knowledge drawn from the experience. According to Georgiou, Zahn and Meira (2008, p. 813):

> The heart of experiential learning lies in reflectively observing concrete experience and actively experimenting with abstract conceptualizations.

Thus Dewey's 'learning by doing' consists of (a) engaging with the world through direct experience, (b) reflecting on the concrete experience, (c) making abstractions from the experience and (d) transitioning from the experience to create a plan of action based on active experimentation. In short, experiential learning can enable students to learn by doing, embodying, reflecting and understanding their problems and challenges.

How does the integration of mathematics and arts education come into the question of Freire's 'problem posing education' and Dewey's 'learning by doing'? Perhaps the critical pedagogue, Shor (1987), provides a plausible answer when he explains that the problem posing process starts with identifying the real problems affecting the community or society. Through dialogue, the community can then apply Freire's codification, described as a concrete physical representation of a particularly critical issue that has come up during the learning process (Shor, 1987, p. 38). For instance, teachers can make use of diverse codes that may include stories, newspapers, magazines, photographs, games, videos and any other objects that serve to represent the problem at stake. According to Shor (1987), an effective code should be open-ended, and does not provide ready-made solutions. On the contrary, any solutions should emerge from the dialogue, reflection and action of the group. The code should have relevance to the group's reality in order to enable that group to:

> describe what they see, define the problem(s), share experiences, question why there's a problem, and strategize what they can do about the problem (Shor, 1987, p. 39).

Indeed, the selected case study based on the story *Crossing the River* provides an appropriate framework for an integrated approach to arts and mathematics education. The story represents an effective coding for a mathematical problem in a manner that demonstrates Eric Jensen's assertion that, "There's no separation of mind and emotions; emotions, thinking and learning are all linked" (Jensen, 1998, p. 2).

The integration of mathematics and arts education, therefore, debunks the long-standing argument that treats mathematics as a cognitive thinking and rational left-brain activity, while the arts are considered to be an affective, feeling and emotional right-brain activity. Jensen (1998) further argues that arts based fields like music would be nothing without the mathematical elements of time, motion, tempo and beat. Similarly, movement would be impossible to choreograph without counting the beats. In a way, the integration of the arts serves to concretise the abstract concepts associated with mathematics education. Thus integrating the arts with mathematical concepts not only builds bridges between hitherto dichotomous disciplines, but also brings a much more refreshing, enjoyable, yet creative quality to the learning of mathematics. It makes it much more comprehensible to those who would otherwise remain less inclined towards doing mathematics.

## 4.0 The *Crossing the River* story as case study

*The story as problem*

Two adults and two children come to a river on their way to a family wedding. The children find a small automatic boat on the river bank. They discover that the boat will hold one or two children, but only one adult and no children. How must they cross the river? If the boat owner charges R50 per trip, how much will the family pay to cross the river?

*Activity*

Let us denote the movements as follows: Since there are 2 Children and 2 parents, C will indicate Child, P is Parent, F is going forward, and B is going backward. The first trip will consist of both children going forward to the other side of the river (i.e. 2CF). In the second trip, one child will return (go back) with the boat to the original side (i.e. 1CB), and then one parent will get into the boat to get to the other side (i.e. 1PF). Proceeding in this way, we have the following trips: 2CF, 1CB, 1PF, 1CB, 2CF, 1CB, 1PF, 1CB, 2CF, giving a total of 9 trips when we have 2 children and 2 parents/adults. Therefore the family will pay 9 x R50 = R450 for the use of the boat. When an Uncle joins the family, how many trips will be made? One finds that we need an extra 4 trips. This means there will be 13 trips when there are three adults and two children. Proceeding in this way, and when we increase the number of adults, we come up with a pattern that can be summarised as shown in Table 1.

**Table 1: The general pattern of trips made by children and adults**

| Number of parents (n) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Number of children | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Number of trips (T) | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 |

It can be seen that since there is a common difference of 4 trips as we move from one column to the next, we obtain the following as a general pattern (formula) for describing the number of trips (T) when we change the number of adults but keep the number of children to 2. When we increase the number of adults, we increase the number of children travelling together by one more trip. Hence, the linear equation formula will be as follows: $T = 4n + 1$

*Comments*

Most of the participants who gave comments on the crossing-the-river activity were teachers (GET and FET) who were doing a BEd Honours programme in the Faculty of Humanities at Tshwane University of Technology (TUT). About 35 to 40 students were involved in the activity. The teachers come from different Provinces that included Limpopo, Mpumalanga, Gauteng, Free State and the Northwest.

The voices of these teachers highlight the importance of 'bringing learners to mathematics'. We claim that the underperformance that often characterizes the problematic classroom experiences of many learners arises from pedagogies that strive to 'bring mathematics to learners'. Such pedagogies pay little recognition to the need to bring learners to mathematics. To bring learners to mathematics means that we need to know not only what mathematics is about, but also who the people are. We argue that play is the stage that levels the playing field for learners and teachers of mathematics. Play is the stage that unveils the inner stage that bonds mathematics and learners. Through play, learners become engaged and sufficiently glued to that stage.

We now introduce you to the Crossing-The-River activity and present voices from what the mathematics teachers said after taking part in the performance of the story. After the performance, the teachers were asked to respond to a questionnaire that had five close-ended and open-ended questions. The instructions given to the teachers were as follows: You are required to reflect on the Crossing-The-River activity and write detailed comments based on what you observed and experienced in today's mathematics class. Write down your reflections using the following leads:

(i) According to my observations from the Crossing-The-River activity, mathematics is ..............................................................................................................................

(ii) According to my observations from the Crossing-The-River activity, mathematics is about ................................................................................................................

(iii) I learned the following mathematics ideas from my participation in the Crossing-The-River activity, ...................................................................................................

(iv) I liked the Crossing-The-River activity because ..........................................................

(v) My other comments on the Crossing-The-River activity are as follows ..............................

The activity was intended to demonstrate the nature of mathematics as a key focus in the first term module on didactics of mathematics taught in the Faculty of Humanities at TUT. The following comments were made.

**(a) Comments linked to 'the nature of mathematics'**

> ***T1:*** *I have learnt that mathematics problems are interrelated with our daily lives so in order to solve problems we must demonstrate the problems or give the problems life, we can do this by either role playing or demonstrations. And also I learnt that it's easier not to rush to formulas right away but to solve the problems manually where applicable, because by doing this you will understand how the formula came about or how it was derived…. Mathematics is not abstract or from another planet but this activity showed me that things that we do in our daily lives have mathematics. Again it showed me that most of mathematics problems can be demonstrated or role played in order to make someone understand better.*
>
> *This activity made me to see mathematics in a different way than before, my mind has shifted from thinking that mathematics is about equations and formulas rather it showed me that mathematics is interrelated with our daily lives… I think as teachers we also should stop teaching mathematics as an abstract subject but try to make demonstrations and role plays that learners would understand. And one thing for sure learners enjoy a subject when they realize that they interrelate with it. I think this will make learners enjoy the subject compared to before. We should make examples that they see in their daily lives. Those kinds of activities make you think, they make you participate and I think if you took part in something you will never forget it in your life. I now know that when I see a mathematics problem I should give it life by demonstrations or role plays.*
>
> ***T2:*** *Mathematics is just a subject that communicates with individuals based on*

*practical observations. It is the subject that requires full attention of the student and gives more attention to what is being observed. Mathematics in this activity is an eye opening and mind opening subject that enables one to come up with their own ideas and extend further in visualizing from observation so that one may not forget the next time they solve problems.*

*Mathematics is about paying attention and giving full focus on scenarios, and also making notes in every observation. It is about understanding what is needed and what is not needed or allowed in the process of solving problems. It is also about understanding patterns and coming to know the difference in the process of practical activity as the river-crossing-activity was done in class. It is about understanding what changes occur when an adult was added to the family and what formula to use in coming up with a solution to crossing the river.*

**(b) Comments linked to 'performing mathematics'**

***T3:*** *I learned the following mathematics ideas from my participation in the crossing river activity. I learned that you can teach mathematics without using any tool such as a textbook because mathematics is a practical based learning area and not a theoretical one. It is very interesting and more enjoyable. I have also learned that as a mathematics teacher you can use your learners as teaching aids in class in order to perform practical examples so that your learners can understand your lesson far better and enjoy it. I liked the crossing river activity because it has taught me a lesson that as a mathematics teacher you need to make the subject more interesting by ensuring that you don't always stick to the textbook whenever you are teaching the kids, but perform some of the activities practically so that the learners can see the nature and importance of mathematics.*

**(c) Comments linked to 'everyday experiences'**

***T3****: Mathematics is part of nature. In this activity there was a family that needed to cross the river so that they can attend a wedding. They were using a boat to get to the other side of the river… The number of adults kept on increasing until we got a linear number pattern.*

*Mathematics is formulated from what is really happening in our life. From this activity I think people who invented mathematics observed what is happening around us, and then came up with possible solutions for the problems that human beings may come across. I am saying this because in this activity what the family went through in order for them to reach their destination might happen to a real family who live in rural places where there are rivers*

***T4****: Mathematics is doable. It is difficult yet doable. From the river crossing activity I realized that mathematics is what we do every day, the way [we] think and the decisions we have to make.*

*Mathematics is about dealing with the logic of numbers, shape, quantity and arrangement. Mathematics is all around us, in everything we do. It is the building block of everything in our daily lives, including art, as well as the arrangement of objects.*

**(d) Comments linked to 'pedagogy'**

***T5****: It was interesting, enjoyable and a little bit challenging. At first it was challenging to figure out the solution on my own, but after the first trip I was able to see what was going on. The way it was enjoyable I couldn't stop to add more adult relatives* *in order to see how many trips I would have. It also made me see that every problem that one may come across has solutions… learning is more interesting when you learn using what is happening around you… one figure[s] out solutions more wisely when he puts himself in the situation.*

## (e) Comments linked to 'creative and critical thinking'

***T6:*** *The activity involves creativity and imagination to discover the solutions. When crossing the river the family had to consider the amount of money they were supposed to pay. Therefore creativity was also needed*

***T7:*** *I liked the cross river activity because it helped me acquire problem solving skills, to be a critical thinker or think out of the situation. It also helped to understand mathematics in real life situations. It reminds me why I am doing mathematics as how to teach it by creating scenarios in class that can help learners to understand mathematics better.*

*It is important to think out of the box and to understand certain principles in order to solve a problem. The crossing river activity was reminding us the qualities that are nurtured by mathematics which are the power of reasoning, creativity, abstract or spatial thinking, critical thinking, problem solving ability and effective communication skills.*

## (f) Comments linked to 'mathematical thinking'

***T8****: Most learners will realise that mathematics is not a monster that most of them think it is. Through this activity my reflection is that mathematics is practical and relevant to our daily activities, we just need to realise it and embrace this great subject called mathematics. We eat mathematics, walk mathematics and talk mathematics.*

***T9****: Mathematics is a subject derived from a common activity. It is about concepts that can be derived from any activity that forms a pattern. From the activity of Crossing the River, a pattern was formed. Taking down all results and observations made it easy for us to come up with a sequence or pattern for any given number of kids or adults. So I viewed mathematics differently from that activity. It made me realize that everything that I do every day, something that is a routine can make you think about a mathematical concept and come up with something or pattern for it. It also opened my mind businesswise, when I see someone doing something over and over again, what can I do to actually to improve the situation. So the Crossing the River activity was mind blowing for me.*

## 5.0 Implications for learning mathematics through the arts

The playing of the story highlighted the key connections between mathematics and the arts. Play creates the space, or 'stage', for the showcasing of the nature of mathematics. More importantly, play enabled access to mathematical thinking. This powerful role of play in relation to the learning of mathematics was demonstrated in teachers' comments after participating in the story activity. It was evident that the performance of the story acted as a form of creative codification for 'mathematising' the problem of crossing the river. Through the aesthetics of play, both learners and educators were able to engage in an embodied and experiential learning of mathematical concepts. The creative coding of the problem happened by means of artistic elements of play such as rules, enjoyment, freedom, repetition, imitation and improvisation.

The mood of play, its quality as an activity experienced through enjoyment, described by Brian Sutton-Smith (1997, p. 148) as 'playfulness,' has the capacity to disrupt what people might have expected, such as seeing mathematics as a difficult subject. The intense absorption arising from the fun and joy of participating in the *Crossing the River* activity was instrumental in moving the players to another state of reasoning. The essence of play as fun, enjoyment and celebration provides learners with an unusual access to a fundamental component of their lives which they might have lost in the struggle for survival. Izzo (1997) argues that when people grow up, they often lose the ability to play because they learn judgment, denial and fear. Thus play awakens the 'inner child' that resides in the learners. During the process of enjoying the fun of playing, it frees the players from familiarity, and in the process, creates a new "frame of existence" (Voss Price, 1998, p. 98) that offers learners a sense of freedom from the usual constraints and obligations of reality. It is the freedom experienced within the play frame that provides learners with the opportunity to experiment and generate new symbolic worlds. Don Handelman (1977) asserts that the element of freedom releases learners from being constrained by the consequences of their actions, and allows them to try out new forms of thinking and behaviour that would never have been tried under normal circumstances. The combination of enjoyment with freedom thus tends to alter the usual means-ends relationship, and acts as a basis for altering the usual means of transmitting messages as it camouflages itself in the paradox of play.

Although play appears as random activity, Izzo (1997) asserts that if there is a feature that lends it order and beauty, it is the rules. No wonder that one who breaks the rules of play is deemed a 'spoil sport'. Once a child picks up a stick and declares, 'This is a sword', the others need to agree and accept that it *is* a sword, and remains so until the rules are changed by consensus. The rules of play are not only a significant feature but a 'social contract' that binds the players. The *Crossing the River* activity had a number of rules that held together its imaginary world. For instance, the problem of crossing the river could not have been solved if there were no rules such as limiting the number of people in the boat, the expenses incurred for using the boat and limiting the number of adults who enter the boat.

Rules do not destroy the joy and freedom of play since they are chosen and agreed upon by the players. On the contrary, Gavin Bolton (1984) argues that it is the submission to the rules that liberates the players to engage in the freedom of spontaneous behaviour. The rules also act as constraints that focus the creative efforts of the players, and in the process, increase their imaginative capacity. Hence rules tend to operate within a paradox of spontaneity and restraint to create a gap that affords an opportunity for imagination, creativity and reflection. It is perhaps the binding nature of the rules that enabled learners not to be distracted but to remain focused on solving the problem of crossing the river. Gary Izzo (1997) writes about a '*temenos* of the mind', the mental space that forms the imagination. Augusto Boal (1995) also explains that the 'aesthetic space' liberates the imagination by making all combinations possible. In Boal's own words:

> In the aesthetic space one can be without being. Dead people are alive, the past becomes present, the future is today, duration is dissociated from time, everything is possible in the here-and-now, fiction is pure reality, and reality is fiction (Boal, 1995, p. 20).

As a feature of play, the imagination makes present the non-existent, it animates play. Vygotsky (1976, p. 539) regarded play as "imagination in action." It endows play with the quality of possibility, of imagining what might exist but is not yet present.

The *Crossing the River* story created a marvellous world of make-believe and fantasy that challenged learners to make use of their imagination as a source of creativity. The 'as if' world created by the story formed the basis for organizing learners' experiences. Thus if play is an activity set apart from the real context, imagination is the feature that engages with the fictional context by helping to bring forth the alternative realities that ultimately became the solution to the mathematical problem. Such alternative realities were experienced by learners in the form of repetitions involved in crossing the river. Like what happens in most African cultural performances, singing, drumming, dancing, storytelling, masquerading and ritualizing are experienced with such a steady and unbroken flow that one may be excused for thinking that African culture is a mere repetition of given events. But, as Richard Schechner argues:

> The theatre (or performance) is a paradigm of 'restored behaviour', behaviour twice behaved, behavior never for the first time, but ritualized gestures" (2002:28).

Each performance is therefore never for the first time but a re-presentation, a form of re-behaving, re-performing and re-hearsing. Repetition involves continuity and change, adoption and adaptation, simulation and transgression. Together with spontaneity and improvisation, repetition creates space for questioning, reflection and revision. The spontaneous improvisations that learners engaged in as they tried to cross the imagined river demonstrated the renewing function of play, and in turn, the transformation of mathematical problem solving into an art.

Indeed, Mara Alagic (2007) was persuaded to conclude that the integration of arts and mathematics education does not only play a significant role in changing learners' perceptions on the value of mathematics, but also challenges cultural norms that make mathematical deficiencies acceptable. Such interplay between arts and mathematics education provides an opportunity for engaging learners in such a way that the teaching of mathematics in isolation may never accomplish.

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