

system and reveals the existence of a Yolŋu mathematical system. However the analysis has not revealed the form which the schema might take in the Yolŋu mind (i.e. the nature of the Yolŋu schematisation of **gurrutu**). That is to say it has not revealed the form of the mental imagery through which the system is held, nor how it is acquired.

## Implications For Educators

The presence within Yolŋu society of general mathematical activity (i.e. recognisable in Western terms), together with a discrete **gurrutu** mathematics (for which only selected structural aspects bear a Western mathematical analysis), raises significant implications for educators working in the Yolŋu context. It becomes no longer acceptable to operate under the premise that Yolŋu are situated at some distant, backward point on some imagined mathematical developmental continuum. Such a view not only fails to acknowledge the abstract mathematical sophistication of the **gurrutu** schema, but also carries the quite ethnocentric assumption that there is only one (i.e. Western) valid mathematical continuum.

It becomes incumbent upon mathematics educators to develop an awareness and some understanding of the nature of the mathematical framework or "mind set" that Yolŋu bring with them to the school or tertiary learning situation, and of the developmental pathway which a Yolŋu child follows towards the attainment of Yolŋu mathematical understanding. Both of these (mindset and developmental pathway) stand in stark contrast to their European counterparts.

For the European, mathematical order is cognitively distilled into relational formulae or schematic pictures. Thus the structure of the gene is conceptualised as a double helix, and the atom as a nucleus surrounded by elliptically revolving electrons. The concept of velocity is held mathematically as a relationship or ratio of distance and time ( $v = d/t$ ). European mathematical imagery is manifested physically as diagrams and written formulae. Both involve extensive use of symbolism where the elements of a system are expressed as discrete symbols as are the relationships between these elements (e.g.  $1 + 1 = 2$ ).

As a "paper and concrete" culture, modern Western society is littered with explicit, observable manifestations of European mathematical imagery. For the Westerner looking into the Yolŋu world, evidence of Yolŋu mathematical imagery is easily overlooked. The physical arrangement of participants at ceremonies, the behaviour of people in avoidance relationships, the naming of children, the seating arrangements in a Yolŋu motor car are all manifestations of mental imagery associated with **gurrutu** mathematics.

It is also easy for the Westerner to overlook the insights provided by Yolŋu art, perhaps because the Westerner is used to seeing art as a means of self-expression, for expressing feelings, capturing memories or making a political statement and so on. For the Yolŋu artist, painting is a means of schematising Yolŋu world order in a way parallel to the Western mathematical theorist who constructs graphs and diagrams. Just as the Western mathematician seeks elegance, symmetry and aesthetic satisfaction in such work, so does the Yolŋu artist. Both rely on extensive use of systems of symbolic representation in their abstract modelling of order. It is through coming to terms with the symbolic system that allows another to interpret or read the work.

For the Yolŋu it is the system of song cycles which provide the theoretical basis and rationale for Yolŋu system of order and relationship. The process of schematisation for the Yolŋu theorist/artist involves reducing these texts to sets of theoretical elements and encapsulating through a graphic symbolic system, the order which governs their interrelationships. Thus the paintings which result are valuable in providing insight into the Yolŋu world of mathematical imagery. I am unable to offer the reader a systematic treatment of this Yolŋu mathematical imagery, however I can offer a tangible example of Yolŋu mathematical symbolism and of the role of Yolŋu painting in the schematic representation of Yolŋu mathematical theory.

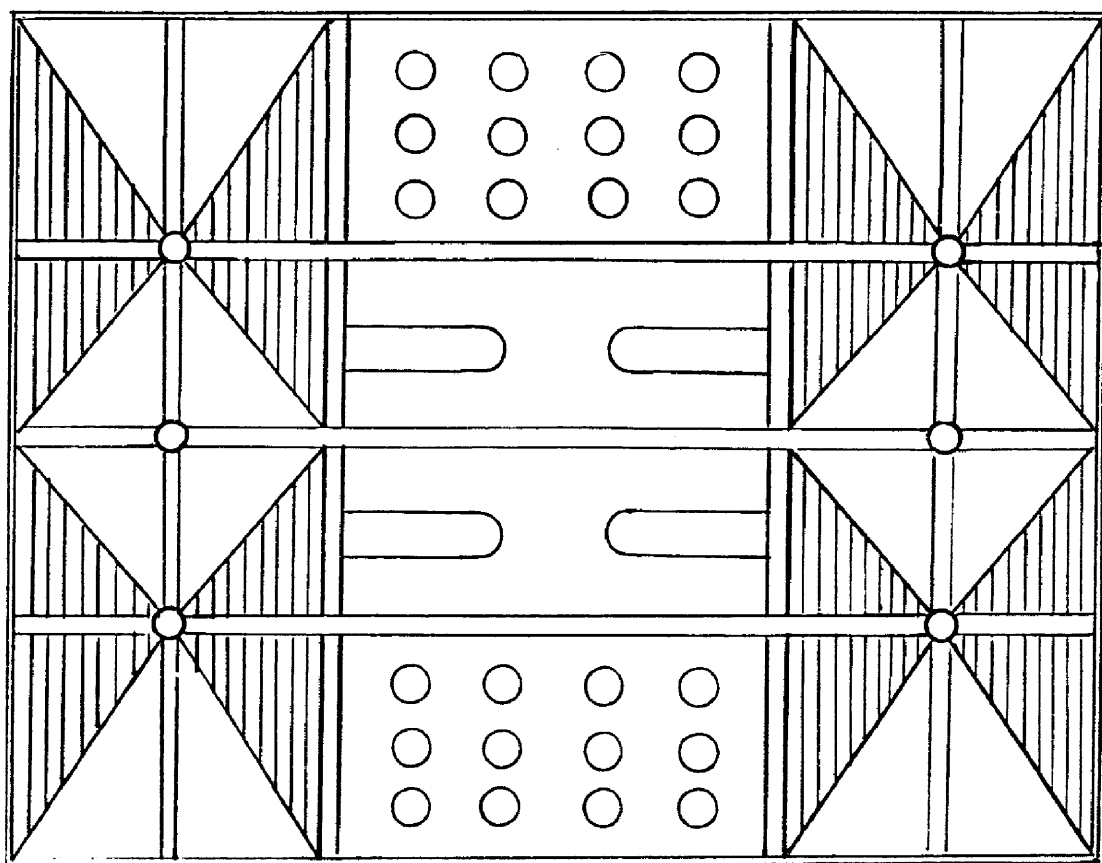
My own consciousness of this schematising role of Yolŋu painting has been developing over the past several years. However it was a recent experience (June, 1990) while teaching Yolŋu students at Batchelor College's Centre for Australian Languages and Linguistics, that gave this idea definition.

As part of her studies one student wrote down a story told by her father, of the Creation Journey of the **Djaŋ'kawu** Sisters. It is the story of the creation of a group of **Dhuwa** clans and languages, and the identification and naming of a series of significant places and totems. With their digging sticks the Sisters also created a series of sacred water holes which hold the life essence of the clans with whom they are identified. In fact this journey is of fundamental significance as a cornerstone of the **Djaŋ'kawu** Song Cycle, which establishes the relationship between clan, land and totem for a series of clans (Warner, 1969). It is told as the story of a journey of the Sisters by canoe, where the events unfold as they travel from east to west.

At the same time as this student was writing the story, her father Burrukala Garrawurra (a respected **Liyagawumirr** clan artist), offered to illustrate the story with a drawing which depicted the journey. In fact he went further and painted a large canvas. In watching the progress of the painting I kept waiting to see pictorial links with the story. I had visions

of a painting replete with totemic animals, women with digging sticks and the canoes. I did not anticipate the design (figure 11) which actually emerged. For myself as a Westerner, the impact of the striking painting was provided by its symmetry (there are two perpendicular lines of symmetry) and Euclidian geometry. For the artist (and other Yolŋu who can read it), it is a schematic representation of the part of the **Djaŋ'kawu** dreaming which establishes (and defines in terms of **gurrutu**) the relationship between the **Liyagawumirr** clan members and a specific area of land at Galiwin'ku.

Figure 11.                    *Liyagawumirr Design* (reduced detail)



(The canvas itself was painted in traditional colours and includes cross-hatching in the shaded triangles and between the vertical pairs of parallel lines. Outlining of borders and similar detailing has also been omitted. This is in agreement with the wishes of a senior Liyagawumirr man and arises from the sacred nature of the design. The modified design is published here with the permission of Gandhuwuy Garrawurra. It should not be reproduced or copied without similar permission.)

From the Western perspective the design is imbued with Western mathematical symbolism and order. From the Yolŋu perspective the design is imbued with Yolŋu mathematical symbolism and order. Thus in both worlds the the design has mathematical meaning because of the fact that the different mathematical systems happen to share a group of

common symbols. *This is not to say that the common symbols share a common or related meaning.* Thus this design provides an opportunity to demonstrate how easily a superficial analysis of mathematics in the Yolŋu cultural context can misinform the researcher. For in holding out the design as a Yolŋu example of Western or pan-cultural mathematical thinking, the observer may be blinded from recognising this separate Yolŋu mathematical schema, carrying its own mathematical symbolism and based in an altogether differently constructed meaning system. The Yolŋu who is reading the sacred painting depicted in figure (11) is as far from thoughts of right angled and isosceles triangles, as the Christian is from thoughts of intersecting perpendicular lines when he or she prays before a cross.

At this point it may be instructive to briefly examine the role of socialisation/education in the development of Yolŋu and Balanda mathematical schema at the level of the individual, and in the context of schematisation as a cognitive process. (There is already a substantial literature with contributions from writers such as Stephen Harris, Michael Christie and Beth Graham (e.g. Harris 1984), on the different orientations of Yolŋu and Balanda enculturation/learning processes.)

All humans are faced with the need to bring order to their experiences and in doing so we form our (ideational) worlds. We do this in the context of our particular society and its culture. A culture holds the framework which guides us into accepting the way our society patterns reality and brings order to it. Classification of our experiences and environment is a process of patterning. Our individual cultures provide many of the categories and the criteria for sorting. As we recognise and internalise the patterns we are able to abstract from patterns the 'rules' which govern them. The behaviour of schematisation is a cognitive process where experiences are first patterned and classified, where rules are abstracted and organised, where sets of rules are internalised and interlinked, and when finally the real world is re-evaluated according to this very schema which, though first negotiated and constructed from the world, is now able to be separated and abstracted from it. This behaviour is common to both European and Aboriginal societies (as I imagine it is to all human societies). The following is an example of how one schema specific to European cultures might develop, offered in the form of a composite idealised word picture:

European children through running (playing) and driving in cars, develop a concept of speed. Later on they learn to conceptualise and quantify speed in terms of units of distance and units of time, these units being set in relationship to each other (i.e kilometres per hour, metres per second etc.) rather than in terms of degree of excitement or fear. Acceleration also emerges as a concept distinct from speed (with which it is first identified) out of experiences such as the feeling in one's stomach which occurs

when a lift begins to ascend or descend, or when riding in a "hot" or powerful car. Later we learn to quantify this in terms of rate of change of speed, measured for example as 'metres per second per second'. For a car we learn that speed and acceleration are functions of (amongst other things) the engine size or capacity (measures in terms of cubic centimetres or litres), and the efficiency of the engine in converting the pressure generated by exploding petrol into mechanical energy as the expanding gases push the pistons. We learn to conceptualise the process as a realisation of the potential energy which is released from the formation of chemical bonds during ignition between the hydrocarbon fuel and the oxygen in the air, and we learn to quantify these process in terms of units of temperature, pressure and volume and in terms of the relationship (empirically derived) which governs them. We learn that petrol as an organic fuel derived its energy from the rays of the sun which provide the means for carbon dioxide to react with water to produce the carbohydrates (yielding hydrocarbons) from which petrol is derived. This can all be learnt by the school child at a senior high school level. Finally at the university level, through a system of physical laws derived from observation and experiment (i.e. from experience) and yet defined, quantified and inter-related in terms of concepts of mass, energy space and time, we can trace a direct pathway, mathematically described between two events separated by millions of years and millions of miles - atomic fusion millions of years ago in the sun (at the time when our fossil fuels were growing plants) and that feeling in the pit of the stomach as we stamp our feet down on the accelerators of our very fast cars.

This schema which both derives from Western culture and yet at the same time shapes it, is again a whole system derived from Western societal experience and negotiated within Western society's chosen (and evolving) metaphoric parameters. Of course it is hardly necessary to note that while many adult members of a Western technological society are familiar with basic details of the Western mathematical system, and are able to apply their knowledge to measurement, quantification, and number operations, very few indeed are masters of mathematics at a theoretical level. Relatively few people can even claim to have acquired and internalised the nature and structure of the system as an integrated, detailed and ordered schema.

There is a parallel in Yolngu society with respect to the **gurrutu** schema. In exploring the schema with individual Yolngu, and in listening to Yolngu discuss **gurrutu** issues (a very common subject of discussion), it is apparent that a deep understanding of the structure at an abstract, generalised level is by no means universal. All adult Yolngu are of course able to name and explain relationships within their own family and clan networks. However in generalising, many Yolngu hold a **gurrutu** model

based on the patterns of relationships within their own family networks, and yet the patterns can change from one family network to another. This may be because some people have taken the "wrong" marriage partners according to rules governing family relationship, clan relationship or subsection. Such marriages alter the pattern within a family network. It is the elders who must often, operating from their knowledge of the abstract, idealised system, work through the ramifications in such cases, and who sometimes re-organise relationships within members of a family to restore order and balance to the pattern of relationships in the whole network.

A full understanding of **gurrutu** at the theoretical level is the mark of a well educated middle-aged or elderly Yolŋu. Such people are able to call upon a deep and detailed knowledge in a variety of domains which include the social and creation history of many clans, the geography and physical features (together with their cultural significance) of large tracts of land and water, the natural history and interrelationships of elements in the natural environment, the content and conduct of many ceremonies and the ability to interpret the art of many groups. Such knowledge provides the basis for enunciating, interpreting and negotiating the interrelationships between clans, languages, countries and ceremonies, all of which influence the determination of the relationship (in the full sense of the word) between one individual and another.

The pathway to such knowledge, as for the European child developing in Western mathematics, begins at infancy and constitutes a development through progressively more abstract levels of cognitive schematisation. (Also as with the European child, the opportunity for learning mathematics is affected by environment and lifestyle. For the Yolŋu child living in a homeland centre (outstation), the fireside, where the old people are usually found sitting, is in the evenings the focus of the family community and a centre of learning. In the larger communities television and video and take up much of this learning time. Streetlights and community buildings around which young people congregate at night time, also tend to supplant the fireside in importance.)

In outlining the different pathways to knowledge in the European and Yolŋu societies we should bear in mind a fundamental philosophical distinction. The development along a Western mathematic/scientific pathway to knowledge is based in a conceptual separation of the human mind from nature and from the cosmos in order for their elements to be objectively explored and interrelated according to a logical framework built around defined notions of empiricism, rationalism and scientific method. On the other hand the Yolŋu schema retains the individual psyche as a corporate part of land, nature, cosmos and the spirit world. The Yolŋu looks and learns from within, rather than from without.

The following is offered as a composite idealised word picture of how one Yolŋu schema might develop:

The Yolŋu child is integrated from infancy into an extensive social network where everyone is explicitly identified first and foremost according to relationship. This is constantly and consciously reinforced in all social interaction. Living in a story telling culture the Yolŋu child begins a comprehensive cultural education at an early age. These stories are no fairy tales, myths or legends. Each story, whether about creation events, the spirit world or a moral lesson, is told as truth. The relationship to the child listener of the characters, country, clans and animals which feature in these stories, are made explicit (in terms of **gurrutu**) as the story unfolds. Thus the identity of the child with the Yolŋu world is built. (A colleague told me of a seven year old Yolŋu child attending a Darwin school, who upon seeing the teacher hold up a picture of a whale, exclaimed in English, "That my mother!" His pride turned to bewilderment as the rest of the class laughed at his "joke".)

The child moving into puberty has already learnt to behave appropriately towards others according to relationship, and already knows how s/he stands with all those coming into daily contact, even without knowing their personal names. In accompanying older people on hunting trips or in travelling to funerals and other ceremonies, the older children are already consciously aware (and if not they are told) of their relationship with the country they traverse. Periods of formal instruction augment the informal (though purposeful) teaching of the child's closer adult relations. For boys in particular, such formal instruction often occurs as they participate in ceremonial life at progressively deeper levels. Some of the song cycles which they have heard over and over for many years (and which they also know in story form) take on deeper and more explicit meaning.

The Yolŋu adult has progressed to an understanding that the ritualised crying of the older women in mourning can follow the same words as the men sing in their song cycles, and that the ceremonial dancing and the bark or body paintings are complementary forms of the same teachings. They all serve to instruct and reinforce the nature and identity of the relationships which bond and order the elements of the Yolŋu world and cosmos. Thus finally as masters of this knowledge, the old people continue the tradition of negotiating together the refinement and adaptation of their theoretical model to reflect the changing realities of their dynamic world.

In today's context the realities of the Yolŋu world include the immense (and in many respects overwhelming) forces of the Western world, one of these being "education". Within the Western education system educators are struggling to impart to Yolŋu an exotic system of world ordering in the form of mathematics and science curricula. It is a system few Yolŋu acquire, and there is a multitude of reasons as to why this might be so. It is not my purpose here to analyse the failure (nor to argue about who it is that is failing). Rather, I have selected Aboriginal teacher education as a situational context in which to present and illustrate some of the educational implications which emerge from the body of this paper. The recent rethinking of the mathematics curriculum for Aboriginal teacher education students at Batchelor College makes this a dynamic context.

## Aboriginal Teacher Education

During the past two years the Teacher Education Mathematics Curriculum at Batchelor College has been radically revised. Previously the curriculum was squarely based on the teaching of Western mathematics, quite divorced from the social context of Aboriginal communities. Stanton (1990a) describes the orientation of the new curriculum (to be implemented in 1991) which promotes the exploration of Western mathematics as a socially negotiated and culturally contextualised meaning system. It seeks to identify ...

ways which de-mystify and make (Western) Mathematics accessible to Aboriginal teacher and child alike; ways which allow the the Aboriginal community to co-opt (Western) Mathematics, its symbolic technology and machines for their own purposes.

A primary focus on the new curriculum will thus include community based research where students will ...

look for and celebrate the mathematics which is to be found ... 'frozen' in Aboriginal tradition. ... Whether or not they may come to identify bridges between their own cultural ways of knowing and that of M.T. (Mathematico-Technological) mathematics will be subject to their own professional judgement.

The curriculum specifically draws a distinction between two meanings of the word mathematics. One refers to the mathematics of the Mathematico-Technological or Western culture, and the other to mathematics from a pan-cultural perspective.



Michael Cooke, 1990

AIATSIS Library, PMS 4915

“Seeing Yolngu, seeing mathematics” page 37 to 44 (m0069594\_v\_p37to44\_a.pdf)

To cite this file use :

[http://www.aiatsis.gov.au/lbry/dig\\_prgm/e\\_access/mnscript/m0069594/m0069594\\_v\\_p37to44\\_a.pdf](http://www.aiatsis.gov.au/lbry/dig_prgm/e_access/mnscript/m0069594/m0069594_v_p37to44_a.pdf)

© Michael Cooke