MATHEMATICS TEACHING-RESEARCH JOURNAL ONLINE
VOL 7, N 3
Spring 2015

The limits of a rational mind in an irrational world - the language of mathematics as a potentially destructive discourse in sustainable ecology.

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Keywords:

Sustainability, mathematics, rational, education, language, metaphor, systems ecology

Abstract

The rational language and ideas of mathematics have been created and adapted by humans over millennia. The ideas of number and arithmetic are fundamental to central concepts of civilian life. It becomes easy to forget that mathematics is a metaphor for our understanding of the Universe. Mathematics tell a story about the universe. The language of number and operations allow the human to extend thinking about concepts within the universe. Mathematics is not however, a perfect tool for understanding. It is a good story, but a story nonetheless. It has some very powerful features which support and articulate the human mind that developed the threads of mathematics. It also has some limitations. The collective human rational mind that created mathematics wants to believe so strongly in the predictive power of the story that sometimes the story is more powerful than the irrational reality which it describes. When is mathematics not a good tool? George Orwell's character Winston Smith, in 1984 (Orwell & Prebble, 2007) is forced to accept the absurdity of the notion that 2+2=5 if that is what he is expected to believe.

"You are a slow learner, Winston"

> "How can I help it? How can I help but see what is in front of my eyes? Two and two are four."
>
> "Sometimes, Winston. Sometimes they are five. Sometime they are three. Sometimes they are all of them at once. You must try harder. It is not easy to become sane"

And "Freedom is the freedom to say that two plus two make four. If that is granted, all else follows" To what extent do we accept the status quo because of the established social pressure to do so? Can the irrational world be modeled by mathematics?

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Steven Arnold is a senior lecturer in AUT (Auckland University of Technology) his interest in mathematics education requires him to consider how the ideas of mathematics are passed on from generation to generation. It was in noticing that one consequence of passing on of these ideas, is that we have to give up other ideas. Are the mathematical ideas so robust that they can't be challenged? Starting with an exploration into sustainability in the University, Steven was lead through his teachings to challenge some of the fundamental notions of mathematics, arithmetic and number.

Sustainability

Sustainability is a concept far beyond the conservation of energy and resources. It extends even further than the responsible transmission of effective guardianship of our planet to subsequent generations. The concept of sustainability challenges us to delve into the content and the structures of the acceptable ways of being.

Capra (Fritjof Capra, 2004) reminds us of the systems found within nature as an appropriate basis for our supernatural systems; noting that:

> "It is becoming ever more apparent that our complex industrial systems, both organizational and technological, are the main driving force of global environmental destruction, and thus the main threat to the long-term survival of humanity. To build a sustainable society for our children and future generations, we need to fundamentally redesign many of our technologies and social institutions so as to bridge the wide gap between human design and the ecologically sustainable systems of nature.[1]"

What aspect of the **system** might we consider ready for change?

The United Nations collective wisdom found in the Education Science and Cultural Organisation document articulate that sustainability is emergent thinking.

> "Sustainable development, a constantly evolving concept, is thus the will to improve everyone's quality of life, including that of future generations, by reconciling economic growth, social development and environmental protection." (*UN Decade of Education for Sustainable Development, 2005-2014: the DESD at a glance; 2005 - 141629e.pdf*, 2014)

As sustainability is evolving, changing definitions will be needed. Phrases such as 'improve everyone's quality of life', 'future generations', 'growth' and 'development' have a long established pedigree in education.

The Sustainability Math Home page summarise as follows

- The current state of people is not a morally acceptable endpoint of societal development.
- Humans have reached a state where we are negatively impacting the ability of future generations to meet their needs and aspirations.
- The major types of problems facing humanity have to be addressed simultaneously: there is no ranking of importance.
- The "System" requires fundamental changes. (Sustainability Math Home Page, 2014).

Sustainability depends on concepts of systems thinking; renewable, recyclable and reusable energy flows. Understanding sustainability requires a holistic mind that is aware at once of the local and details level, while simultaneously being globally and dynamically focused. Sustainability encourages an appreciation and celebration of networks, beyond ego-centric to eco-centric. The finite world that we live in needs a different story to the linear, cause and effect and predictable simple dynamics found in our current discourses. We need more than the perceptual world of mathematics to solve problems. The delicate, and finite systems of the global ecology require careful awareness and management, and sustainability thinking needs flexibility and futures-focused problem solving to approach complicated and complex ecologies.

The concept of sustainability is a relatively recent arrival in the educator's lexicon, being popularised as recently as 1965 with the meaning "capable of being continued at a certain level" (Harper, 2001). In this context, sustainability also carries the idea of the judicial and prudent relationship to the consumable components of the finite ecology. Does engagement with the well-known structures of the philosophy of mathematics nurture responsible and ecological modes of thinking?

Maths and Sustainability

When Descartes declared "Cognito, ergo sum"(Watson, 2007) he hailed the rational mind as central to existence, he also joined the worlds of algebra and geometry in his Cartesian plane. Maths, as a model for rationality, was to provide a model for the world. However, we can now see some of the consequences of this world view.

Perhaps the simple, yet powerful, language of maths itself precludes a responsible sustainable world view? Some simple examples may assist in rethinking mathematics and the potential that 'education' has for numbing us to our real world. For example: how can we justify teaching students of the arithmetic concept of "takeaway" when we also live in the real world? When can you takeaway anything? We can't take away rubbish, we only move it out of sight, and even that is just temporary because at the same time we introduce notions of the finite planet as a closed system. What is happening when we say “I have five lollies, and take two away”? Where do the other lollies go? Who gets to eat them?

Through my teaching, research and reflections, there came a realisation that one of the ways in which we process sustainability concepts, are captured within the curriculum ideas themselves. For further clarification, and by example I decided to test the ideas of mathematics, specifically arithmetic and number; in terms of sustainability. My teaching of mathematics forced me to consider carefully some of the components of a mathematic curriculum.

The ideas presented in mathematics do not tell the complete human story. They do not tell the whole story of our planet. The thought occurred to me that the very notions of mathematics, may be representing ideas that inhibit notions of sustainability.

So my questions became "to what extent does the engagement with the well-known structures of the philosophy of mathematics nurture responsible and ecological modes of thinking?" What engagement is needed to reflect critically on the role of maths thinking in sustainability?

Education has many functions, one of which seems to be the transmission of received knowledge. The ideas themselves which have been conveyed from generation to generation mould and shape our ways of thinking. Much has been written on the education reformation and these have centred mainly on politics (who), pedagogy (why), delivery (how), syllabus (when) and assessment (which) practices. What adjustments can be made to the ideas of curriculum content (what)?

Futures thinking offers a new set of tools for engaging with the content of the curriculum. Without delving too much into the emerging structures of complex analyses of education, what emerges in futures thinking is a different approach to education. The 'building blocks' of education; content, knowledge, learning, teaching and assessment morph into new constructs such as languaging, discriminating, co-constructing, third space potential and diagnosis. For now let us just focus on the content of the curriculum.

The study of Mathematics is an interesting curriculum area in that it corners a high profile within the curriculum hierarchy. Ken Robinson (2011) argues for the elimination of the curriculum hierarchy, as there are limitations to the positivist nature of the way ideas are taught within schools. The ideas of a curriculum hierarchy is also challenged by postmodern theorists as Slattery (1997) points out.

Is there something in the mathematical ideas that might inhibit notions of sustainability? Dare we even question the rank of knowledge gleaned by generations? Can we suggest that some ideas – fundamental to our understanding of self – have come to time that they no longer serve all of our needs?

As many authors (F. Capra, 1997; Fisher, 2013; Lovelock, 2000; Orr, 2004; Sahtouris, 1999; *UN Decade of Education for Sustainable Development, 2005-2014: the DESD at a glance; 2005 - 141629e.pdf*, 2014) have done before me, I started to consider sustainability and education in a different way.

Nature

An alternative to using mathematics to control, predict or diminish nature is to use wisdom found from da Vinci. Fritjof Capra's book "Learning from Leonardo: Decoding the Notebooks of a Genius" (2013) shares insight into the mind of Leonardo da Vinci who became aware, 500 years ago, that nature should be a central synthesising agent for the increasingly disparate modes of study. The idea of nature as a guide for education is not new. The word environment is commonly used as synonymous with 'nature'.

The return to 'nature as the guide' is an extremely challenging and subtle reflection and challenge to our received wisdom.

Right and Wrong

The pervasive mathematical framework exists strongly within our education system. An analysis of these ideas starts to challenge some fundamental concepts. The well-loved, and familiar concepts of mathematics themselves started to unravel. The simple, familiar and friendly ideas of the universe that had been 'hard wired' into our brains could be represented *by* mathematics but not represent them entirely. This became disconcerting, disorientating and disturbing. Through traditional schooling methods, we have all been taught mathematics in a way that leant an absolute certainty – mathematics were a set of ideas and they were right. In exploration, though, there is a realisation that some ideas didn't sit right in our world. Mathematics solutions can be simply marked right or wrong, and, so maths maintains a unique place in the school curriculum as having a stark, high stakes, bipolarising quality.

Ideas that students of mathematics have taken for granted ever since their own schooling, as fixed, can become exposed as open for interpretation when the concepts of the apparent absolute, reliable and omnipotent structures of mathematics are explored. The questions raised confront the very nature of mathematics.

In fact the notion of right and wrong, which mathematicians value so much sits at odds with our pluralistic and dynamic understanding of the world. Here we have an entire system of thought based on right (and therefore wrong), which is in itself an unsustainable ideology. From that simple predictable approach to the world of absolutes, where logic commands, and algorithms produce predictable outcomes, comes a way of thinking that is often at odds with our own irrational world and ways of being.

Counter intuition

Many of the different concepts of mathematics are counter intuitive. Imagine the concern when first a child is introduced to finding infinity in a finite space. For example I say to the students "how long will it take for me to jump to the door if each jump halves the remaining distance?"; they realise that halving the distance from here to the door in successive jumps, will last an infinite number of jumps – the door target will never be met. Yet the child's experience tells them that you can just simply touch the door, when you are close 'enough'.

Another example is realising that the number of diagonals in a circle is infinite. Again the concept of infinity challenges us to release the conceptual understanding of the word derived through intuition, sensation and experience and take a leap of faith into reliance on logic.

There is a point where this abdication of trusting the senses becomes perilous ((Abrams, 1996).

Another example helps us to become aware of how much we rely on logic against our own intuition and understanding of the world.

It is because time is continuous and not discrete, that each representation of time is only ever an approximation which leads to the ironic paradox that it is never exactly 2 O'clock. It can be just before two o'clock and just after two o'clock. It can't ever be exactly any given time. Any time is always fractionally before or after the stated time.

Mathematics

Our numbering system is a key to accessing our culture. And numeracy is a highly valued skill and is used as a threshold to higher education, employment, and general social acceptability.

Numbers are a comfortable universal, offered to us from our early days of life. We are surrounded by number as a way of enumerating, and as a comforting cardinal (naming) and ordinal (organising) tool. We have comfort in the existence of numbers knowing them to be 'right' to such an extent that we depend on numbers.

Galileo famously said, "The laws of Nature are written in the language of mathematics." However we realise that this profound statement was while very true, it is not strictly true. There are times when the mathematical understanding of the world breaks down. Now in a time of ecological distress, we need technologies and tools that can match more perfectly our world.

In reality, Mathematics is a highly nuanced poetry that describes the human condition, it mirrors the workings of the human brain (as mathematics is exclusively a product of human thought).

Mathematics tells us our own story, it tells us how the human brain works, and as we strive to make meaning of the world, we do so using the tools available to us; number is one of the ways that we language our experience.

We understand from the progression of numbers, incrementing by one unit at a time, the safety and dynamics of a world that follows simple and immutable rules. Eight is one more than seven. Six is twice three. This comfort derives from endless re-enforcement both from formal mathematics lessons, and from the language developed in the world around us.

There is within mathematics an etiquette of the way we use and apply these rules that is accepted by all, and have to be learned by the un-initiated.

The powerful numbering system is learned early on by young children, and the mastery is often a mark of pride in parents when children learn to recite numbers in order, and later, learn to count (1:1 correspondence).

There is here, a potential challenge to the concept of number itself.

As a founder of mathematical ideas, and an eager sponsor of mathematicians, Plato (Boyer & Merzbach, 2011) aimed to derive a perfect description of the world through mathematics and geometry ("Let none who are ignorant of geometry enter"). Within mathematics there continues to this day an expectation that the simple relationships described in mathematics should be able to neatly describe our complex world. However the real world is not simple, tidy and neat. The real world is full of messiness, unpredictability, human emotion and error. Mathematics describes a predictable world, where error can be eliminated, and it is desirable to simplify and exterminate unwanted complications. Where the two differ, surprisingly it is the human experience in the real world that defers to the all-powerful notions of mathematics.

The simple concept of number only really works in the abstract field of mathematics. Some may choose to argue that numbers are a simple, and neutral tool beyond human value. Numbers, however are far from neutral. Number is a wonderful story device and a great metaphor, it almost works in our real world, but not quite. The same can be said of geometry, statistics, and measurement. Algebra, of course is the purely abstract form of mathematics that exists solely within the conceptual realm.

Numeration

To what extend do the numbers that you accumulate through life, dictate the life you lead. Is someone who gets 97% for physics so much better than the person who got 96.5%? One might get dux, and all sorts of other accolades, the other might drop physics. Equally those who fail one English exam (due to the fact that they speak 4 other languages, and are dealing with the realities of living in a migrant family) may have severely diminished life chances. Does school success (as measured by number in school exam scores) predict life happiness, health, wealth? To what extent are numbers ruling people's choices?

Numbers appear as a powerful predictor of success in our lives, or so we believe. What is the correlation of number to real life? The following example of bananas shows us some limitations of the clean concept of number.

If I have just one banana – it can be eaten as a snack. If I have two bananas, it means that I could substitute them for a light meal. If I have three bananas, there is enough for some friends to share. When I have four bananas I have enough for my immediate needs, and I have got enough for later. With five bananas I have a storage problem.

In mathematics the numbers sit in an orderly line along a number line. Each number bears a strict relationship to others, there are predictable rules for their relative values, and strict applications of how each number operates. 4 is twice 2. 6 is three less than 9. Always.

However in the real world example the strictness of the number systems breaks down: each increment in the number of bananas fundamentally changes the dynamics. It seems there is not a universal mapping of our story of number onto the real world. Even the apparently simple concept of number has more complications than originally thought. Number as quantity is an unreliable metaphor of experience. 5 bananas is not the same as 5 lots of 1 banana.

Quantity and Quality

While counting is one aspect to number (quantitative) there is another aspect (qualitative) of objects which holds another dimension.

If I place an amount of uniform sticks on the table – it is possible to count them. As long as we all agree that for the purposes of the exercise they are similar enough to be grouped together as a homogenous set. Most children become quite comfortable with this 1:1 notion of counting after a while. Piaget (Inhelder & Piaget, 1958) shows it takes some time for the size of the group to be ignored over the 1:1 correspondence; he notes that children will consider there to be more sticks if they are spread further out, even if 1:1 correspondence has already been established.

The child learns to over-ride their intuition and understanding of the real world. Their experience to date is that bigger is more. The child has to let that concept go to embrace the 1:1 correspondence of number to object in the real world. The child learns that the rules of mathematics must be obeyed against the natural sense of experience and natural living.

In another example, if I take some rods of uniform character that are 20, 40, 60, 80 and 100cm long. I could label the first 1, the second 2 and so on. The rods are exactly proportional, in that the 4 and 1 together are exactly the same length as the 5. Where is the '4' ness of the rod? There is only one rod (not 4 individual rods). It is agreed it is '4'. The 4ness is within the quality of the rod, the whole rod is 4; not just a bit of it. In the same way that I am 6 foot tall. All of me is 6 foot tall. It is not that I am made up of 6 lots of 1 foot bits. I have the quality of "6 foot"ness.

Values and Emotions

We put so much faith in numbers, that sometimes we place the power of the digit over the judgement of our experience. This idea of positivism has found a secure home in the teaching of mathematics in schools. We are controlled by numbers, from the early stages of test results, to class position and IQ, to more recently BMI scores, glasses prescriptions, salaries and postcodes. We sometimes forget that numbers are a way to tell the human story. We forget we make them up, not the other way round.

The 16 year old is seen as someone who has more power, is far superior athletically, and generally more cool by the adoring 12 year old cousin. Year 11's have more freedom than year 6's. In many aspects of life it is assumed that it is generally '**better**' to have a bigger number: Salary, IQ, height and so on. In some cases it is **better** to have a lower number: weight, blood pressure, debt. In some aspects of society it is **better** to have a certain set of numbers: postcode, socio-economic status, BMI. The value scale of 'better' exists independently of whether we agree on which quantity is better or not. Number has an emotive and value laden notion. Is it better to be 'smarter' at school? IQ is a very poor predictor of health, wealth or happiness (Noddings, 2003).

The inherent emotive quality attached to some numbers can over-ride other human wisdom. A person may feel fit and healthy, but remain depressed about their weight due to an 'abnormal' BMI. A salary may be sufficient, until it is compared to another. A test score may become a social advancement, rather than a reflection of knowledge. The Chinese have strong identities with the numbers themselves; with the number 8 being strongly linked to prosperity and happiness.

Naming

Numbers are not a neutral label, neither are they particularly consistent in their use as the following examples indicate. When we deconstruct ideas of numeracy further we find some embedded concepts. For example being in the group labelled "4" is not twice as good as being in the group labelled "2". "Room 17" is not one better than "Room 16". The use of number as a naming tool (nominal quality) reduces clarity around the relative value of number.

Ordering

In a race there were 5 entrants: The first person had a time of 1:06.05 and the second had a time of 1:10.08 and the third 1:45.93, the fourth person timed 1:50.87 and the fifth 1:50.89. Here number does not indicate anything else than order (Ordinal quality). It does not tell us anymore than the third person came before the fourth and after the second.

Perhaps there are other times when the number, quantity or amount of things fundamentally *changes in kind* rather than a linear *progression of degree* change. The simple numeration model indicating arithmetic relationships starts to collapse.

Numbers do show a relative status, but is -4 degrees twice as cold as -2 degrees? What does that mean?

Is it better to be taller? To what extent do we gear society to an assumed optimum? We find averages, means, medians and mode. Somehow there are advantages or disadvantages to being close or far from one of these numbers. It somehow undermines and over-rides the inherent human experience.

Operations

Mathematics is a powerful and central tenet in all of our lives. It provides a fundamental language tool in the way of number and operations. It provides an ordering and thinking tool in the form of logic, algorithms, procedures, and theorems.

Numbers have nothing to do with mathematics; just as letters have nothing to do with literacy. It is not the numbers themselves that tell the whole story of mathematics. Literature is the telling of stories of human endeavour and the richness of culture, and making sense of the world. It is not the letters themselves. The letters are simply the medium. Just as number is a medium in mathematics.

The combination and patterns of letters are a useful tool to assist in decoding the texts but do not in themselves carry any meaning. The same is true for number which is a way of telling the rich human story using the mathematics paradigm; logic, reasoning, pattern, relationships and order.

Letters and numbers tell the story, they allow us to record, relive, and reflect on our culture. The various rules of their combinations and distributions such as for letters; spelling, grammar, punctuation AND in number; operations – addition, subtraction, multiplication and division, squaring etc. are simply tools to tell the story. But what if how they tell the story is not quite right. What if the message is distorted by the medium?

Equals

The central tenet of mathematics is the logical notion of "equals", however what is the place of equals in a world where we celebrate difference? The notion of equality in mathematics derives from logic, but when are two things in reality ever the same? So this equivalence is purely a mathematical construct. No two humans are the same, no two events are the same. No two bananas, and in fact no two sticks are exactly the same. Trusting that one thing equals another can be very exposing.

The ideas of equals supports the theoretical notion of equality. Justice is based on equality. If nothing is equal, what do we mean by the term justice? The related term, 'equity' implies inconsistency in treatment to ensure an equitable outcome. For example the handicap found in golf is to even the playing field and give everyone an equal chance at success by giving the more advanced players an initial disadvantage. How can we offer 'an equal footing' to different peoples? The concepts within mathematics need further expansion.

There are some internal paradoxes within mathematics for example the representation of some ideas $1/3 + 2/3 = 0.\underline{3333} + 0.\underline{6666} = 0.\underline{9999}$ (even given the understanding that these decimal fractions continue for infinity) this suggests that 1 = 0.9999… Is one equal to almost one?

Examples

To take a few simple examples of how a new understanding of the concepts in mathematics might assist a move toward sustainability.

Example 1:

If we simply look at number we miss the fundamental point. To consider the nuclear threat. What is the real difference between 8500 for Russia and 300 for France, when we are talking about a nuclear arsenal? The world has experienced two atomic warheads, each able to destroy cities, the current available fire power is 700 times that of the total fire power of World War II. What is the reality of the difference between hundreds or thousands of cities destroyed? We can all be destroyed through the deployment of nuclear war heads. Discussing the number of warheads is meaningless. Even discussing who has what, is also not relevant. While any nuclear war head exists there is a danger to us all. The use of mathematical models as the major tool of reconciling danger, assessing relative risk, and determining the future is problematic in that it undermines the human understanding that any one nuclear bomb is bad enough (the formula or computer model won't accept that 1 = 8000).

The absolute belief in the formulas generated by humans that approximate reality may potentially lead to the destruction of humanity. The world is a set of structured couplings (Maturana, 2002) and feedback mechanisms that are enormously delicate and complex and part of an open system and therefore exposed to many random variables.

What is needed is an inclusive and heterogeneous approach to problem solving that celebrates diversity and seeks input from a wide range of sources, celebrating the richness of group wisdom and futures thinking (Weinberger, 2011).

Example 2:

How can we establish a sustainable world without considering these proportions, for example: a cup of coffee takes 11365 gallons of water per 1 pound or 2500 litres per 100grammes of coffee (Orange County Water District). It is not sufficient to consider the numbers and simply worry about the water shortage. While this is important, the real concern is for individuals who do not have sufficient water, to drink, wash or cook with. This is a real, immediate and personal situation, made clear by consideration of the daily existence of real people. Hiding behind the numbers there lies a real human story. Doubling, halving or manipulating these numbers does not tell the real impact on life without water. Statistics and numbers are often used to create a picture, and we rely on their use to keep us informed. The way that numbers are presented as representing reality, can undermine the real experience and situation.

We need to incorporate other wisdoms to our decision making processes, to that any one narrow paradigm does not dominate and produce further replication of the problems solving seen to date. Fixing one problem while creating another has been characteristic of the 19th and early 20th centuries. Time now to develop other 'soft skills' and centres of knowledge that do not strive to be 'right' so much as to be 'righted'.

Example 3:

A J curve is a simple mathematical tool to show exponential growth. While this model is easy enough to draw on paper, it cannot exist in the finite world. In the end all things come to an end. The concept of infinite growth is applied in two major world challenges: economics and population increase.

A growth model is espoused by the world's finance leaders as important to ensure employability, and productivity within the industrial world. Simply the model cannot exist. In the real world there is a downward pressure of growth due to a limited capacity. There is a finite endpoint. There is irreversible destruction that occurs during the growth, and a point past which growth (in terms of pollution, over mining, depletion of stock, extinction and so on) cannot be reversed.

The population curve is also a J-curve. The statistics below may be considered in isolation as a set of numbers, or may have genuine impact on the human, and Earth story that they hide.

- Half of all the world's life human births are alive today
- At 9:24pm on 24/11/2014 there were 7,276,488,058
- By 2024 there will be 8 Billion people
- The population of the Earth has doubled in my lifetime. (approx. 1970 = 3 Billion, 1999 = 6 billion, 2011 = 7 billion)
- If it is your birthday and you are 60 years old today (Happy Birthday); on the day you were born 2,690,969,572 people were alive - almost 3 times as many people

> are alive now and creating rubbish, and consuming the world's minerals at a much worse rate

How can a J curve have no limit, in a world bound finitely? We all recognise emotionally what a crowded world might be like, but the numbers on a graph do not recognise experiences.

The curve needs to be demonstrated as a theoretical model only, not taken as a descriptive nor prescriptive pattern.

The mathematics of the future may need to involve fuzzy logic (Klir & Yuan, 1995) at an earlier time in the development of ideas; indicating that statistical uncertainty may be a part of the way that we learn mathematics rather than as a black and white absolute.

Conclusion

A new approach to mathematics might be helpful. Encouraging an ecological approach to mathematical thinking, and at the same time encouraging children to challenge established beliefs rather than accepting the dogma. The ecological approach demands an integrated treatment of curriculum, so that mathematics is taught alongside and integrated with human experience.

An ecological approach moves beyond systems (M.J. Wheatley, 2010; Margaret J. Wheatley & Kellner-Rogers, 1998) developing notions of inter-dependence, networks and relationships (Bateson, 1972) expanding the realm of complex forces that co-exist alongside human endeavours.

There remains some ambiguity among commentators (Gallopín, 2006) as to the specific relationship of economics and socio-ecologies. "Persistent disagreement both as to the interpretation to be given to sustainability, and as to the relation between ecological and economic sustainability, has hindered the development of an ecological economics of sustainable resource use." (Common & Perrings, 1992)

Currently mathematics embraces un-sustainable ideas of perfection, predictable patterns, infinite dimensions, perfect relationships, and absolute truths. Mathematicians espouse and expose the danger of 'knowable' and 'correct' bodies of knowledge. In reality some of these bodies of knowledge are not static, they are potentially 'unknowable' and they may at best represent only partial truths.

Our minds tend to rationality (but never quite make it). Rationality – represents a natural limit to the mind; close enough for most of the time, but just like the jumping into the door exercise, the rational mind, cannot ever understand the irrational world. The natural world remains stubbornly irrational. Is it potentially dangerous, or at least misleading to map our sense-making brain onto a world that was not 'designed' for us to understand?

Mathematics is a wonderful tool, an organising principle of logic, patterns, rules and relationships. It does not generate our world. We might need to keep developing ourselves and challenge even more deeply held beliefs to move forward in our collective understanding of how we can support an ailing world; starting with the pressing need for ecological sustainability. The alternatives to mathematics recognise that humans are part of complex adaptive systems. We need complex adaptive technologies and processes to mimic ecology, and protect the complex nature of society and our natural world.

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