

Activities using Both-Ways thinking to communicate foundations and frontiers of ICT to Indigenous children

**Australian Council of Deans of ICT (ACDICT) Learning & Teaching
Academy (ALTA)**

ALTA Final report 2014

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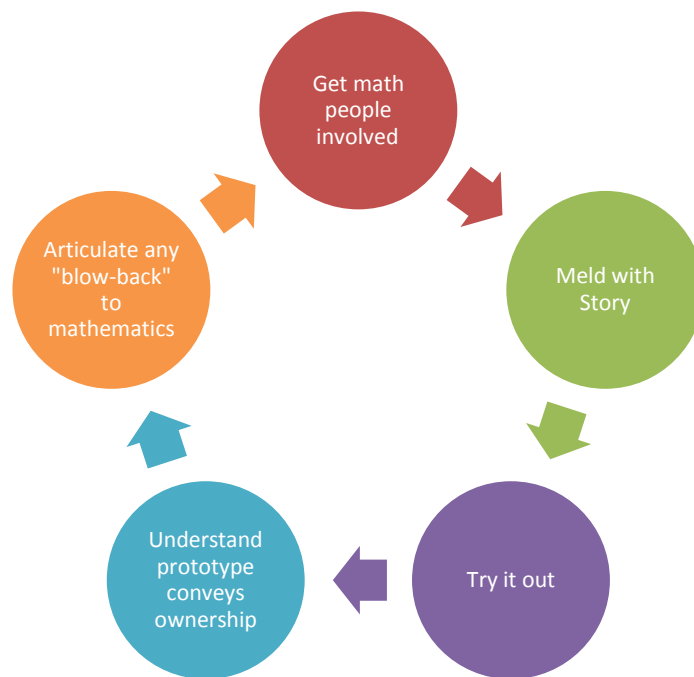


Executive Summary

The promotion of interest in ICT among Indigenous, Aboriginal, First Nations, and other primary school children is a recognized high priority. Many teachers lack confidence and students are not keen about computer technology or maths. The curriculum is not keeping up with the rapidly changing demands of the global ICT sector. Activities and materials are needed to catch student interest and to support teachers in their own computer mathematics understanding and pedagogy.

However, producing such effective activities is a multi-faceted, long-term project.

Whilst the agenda of this project is to create cultural and whole body activities that show understanding and relevance to Indigenous peoples, and connects math with the inner self and community, it is the case that in order to accomplish this goal, there many facets. Therefore, the workflow may be constructed as in the figure below, which reflects the workflow of the project.



- *Get Math People Involved* articulates that experts in the field of computer science - the researchers themselves - must come forward to share their cutting edge ideas in ways that are accessible to children.
- *Meld with Story* tells us to produce holistic, whole-body, storyfull math activities that show *Both-Ways* and *computational ways* of thinking and learning, and incorporate 21st Century Competencies.
- *Try it out* requires testing the activities in the field. Listening to the students, teachers, and researchers. Then, re-engineering the activities to keep accuracy and integrity but satisfy the demands of cost, handiness, and student interest.

- *Understand/prototype conveying ownership* asks that teachers/students should not just use “off-the-shelf” stuff. The students must re-articulate the activity to claim creative ownership.
- *Articulate any “blow-back” in Mathematics* requires looking for ways in which outreach brings new research ideas back to mathematics. There are some examples where outreach to children invigorated or inspired new fields: Game Chromatic Number and Planar Graphs, or Polly Cracker Crypto-systems, for example..

We are extremely grateful to the Australian Council of Deans of ICT (ACDICT) for the 2013 *ALTA Engagement Award* to communicate foundations and frontiers of ICT to Indigenous children. We were able to leverage this seed money to obtain additional funds with which to tackle the broad spectrum defined by the problem. We obtained \$50,000 from Google and \$20,000 from CDU and \$3000 from AMSI .

Thus, ACDICT enabled us to generate additional funding, which brought a large number of international computer science researchers together in Australia, and out to Aboriginal villages, where they were exposed first-hand to the Aboriginal mathematics experience.

The ALTA \$10,000 “angelic seed money” has sponsored the following outcomes that will be discussed in the body of the Report:

1. The development of new holistic, whole-body, storyfull computer science activities activities that show *Both-Ways* and *computational ways* of thinking and learning, and that incorporate 21st Century Competencies.
2. The inauguration of a new research field in Creative Mathematical Sciences Communication, with an international conference series. The agenda of this new field is to imagine and develop new outreach activities to share the foundational, cutting-edge results and inquires of the field with children, and to listen to the experiences with children to enrich and lead to new mathematical fruition.



Participants of the First International Conference on Creative Mathematical Sciences Communication at Woolaning Heritage Christian School, NT. Computer scientist Mike Fellows is demonstrating the Sorting Network.

The ACDICT seed money has led to many unanticipated and important outcomes.
These are described in context later in the Report, but for example:

-Two faculty members in Engineering at Charles Darwin University were so excited about the Sorting Network that they have incorporated it into their engineering courses.

-Verena Specht-Ronique, actress and playwright, wrote and received a grant from the German Ministry of Education to create a theatre production about integrating story and math.

-The Directors and owners of the largest art academy in New Zealand, The Learning Connexion, have developed a degree program on math, creativity and art that is in process with the New Zealand accreditation board.

-Eric Stern, Dancer in the troupe “Two Guys Who Dance About Math” has teamed up with a colleague to institute a new course on mathematics and motion at Weber State University in the United States.

-Nicole Brown, President of Robogals, will take the Robogal program to Oman, as a result of meeting Rosamond and Fellows and making contacts through the project.



This is a street theatre in front of the central banks in Frankfurt, Germany. The “beggars” are using the sorting network to describe poverty.

This is an unexpected outcome of the conference. Homeless people are a “tribe” all over the world.

The work by Verena Specht-Ronique is described on the project blog at www.csmaths.org

Organization of the Report

This Report is organized in the following manner. Section 1 describes some of the activities that have been created, and how they have been implemented. Section 2 describes the plans for encouraging computer scientists to do outreach activities, and the results so far. Section 3 lists the math camps, workshops and other events and the reactions of students and teachers.

1 Activities using Both-Ways thinking to communicate foundations and frontiers of ICT to Indigenous children

This project aims to engage Australian Aboriginal and other children in ICT through holistic, whole-body, storyfull activities embodying *Both-Ways* thinking (Western and Indigenous

language and culture) that communicates the *foundations and frontiers of ICT*, modelled after the successful activities already created for *Computer Science Unplugged!*. Activities use simple materials (string, sticky tape, etc.) and no computers at all (unplugged!) Students use cooperative, whole body, kinaesthetic movements.

The activities of *Computer Science Unplugged!* (CSU) (www.csunplugged.org) and *This is Mega-Math* (www.c3.lanl.gov/mega-math/) were the starting point of the activities we developed. These award winning materials teach abstract thinking and basic ideas of computing using simple materials (string, sticky pads) and no computers at all. Activities are kinaesthetic and cooperative, for ages 6 years to adult.

CSU has been praised by the ACM, by the US Computer Science Teachers Assoc, and is part of a program at Carnegie Mellon on computational thinking. Two of the conference keynote speakers (Mike Fellows from Charles Darwin University and Tim Bell from Christchurch, NZ) are the creators of the CSU project. Google has supported an extensive website for CSU, and there is a dedicated YouTube educational channel so teachers can see how children interact with the activities. CSU is being used by Google in its world-wide CS4HS program. The book has been translated into 19 languages and is used around the world.

The project intention is to take CSU to a whole new orbital by creating activities that include Aboriginal story, and that will show how computational thinking can be incorporated into other subjects with competencies for the 21st Century.

1.1 Computational Thinking and 21st Century Competencies

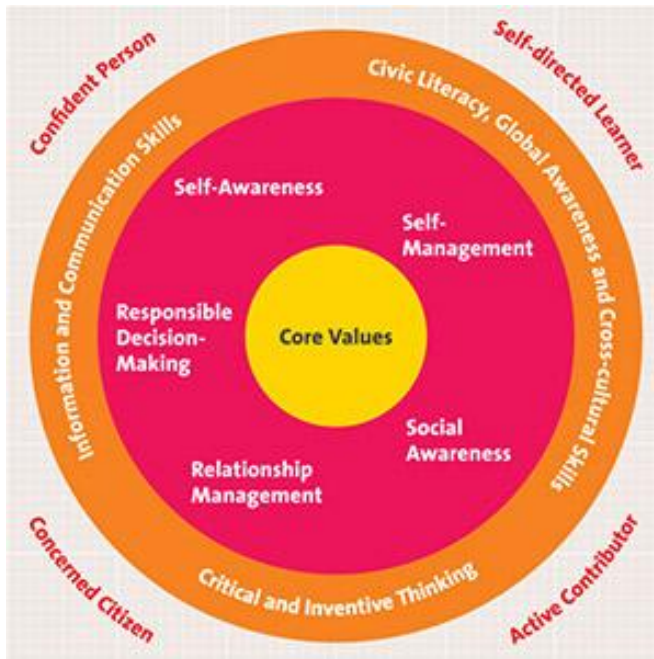
At the 2008 ACM Special Interest Group in Computer Science Education (SIGCSE), Professor Lenore Blum stated that: *Computer Science Unplugged* provides a model of what is now called “Computational Thinking,” a way of solving problems, designing systems, and understanding human behaviour that draws on concepts fundamental to computer science. To flourish in today's world, computational thinking has to be a fundamental part of the way people think and understand the world. Originating in a seminal paper In 2006 by Jeanette Wing, now Dept Chair at Carnegie-Mellon (www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf), the vision of computational thinking has spread around the world. The Center for Computational Thinking at Carnegie-Mellon seeks to advance computing research, and advocate for the widespread use of computational thinking to improve people's lives.

Countries around the world from Alberta, Canada (<http://education.alberta.ca/admin/aisi/themes/21-century.aspx>) to Singapore (<http://www.moe.gov.sg/media/press/2010/03/moe-to-enhance-learning-of-21s.php>) are embracing a holistic, relationship oriented view of education. The Ministry of Education of Singapore says:

The desired outcomes for every student are:

- a confident person who has a strong sense of right and wrong, is adaptable and resilient, knows himself, is discerning in judgment, thinks independently and critically, and communicates effectively
- a self-directed learner who questions, reflects, perseveres and takes responsibility for his own learning

- an active contributor who is able to work effectively in teams, is innovative, exercises initiative, takes calculated risks and strives for excellence
- a concerned citizen who is rooted to Singapore, has a strong sense of civic responsibility, is informed about Singapore and the world, and takes an active part in bettering the lives of others around him.



Singapore



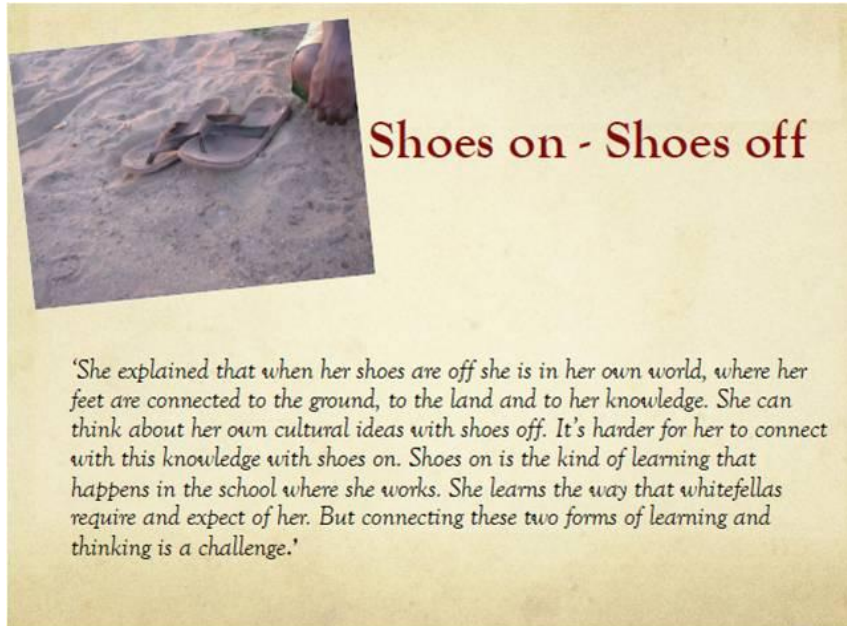
Alberta, Canada

The integrated holistic thinking and social awareness learning style promulgated by Singapore and Alberta is somewhat parallel to Both-Ways thinking. It might be noted that Singapore mathematics scores rank among the most superior of countries taking International Mathematics and Science Study (TIMSS) involving a half-million students in 41 countries. Further, Singapore students who traditionally score low have increased their scores in recent years.

1.2 Both-Ways Thinking and Learning

The activities are designed to be interesting and attractive to children, and to incorporate *Both-Ways* and *Computational* thinking and learning.

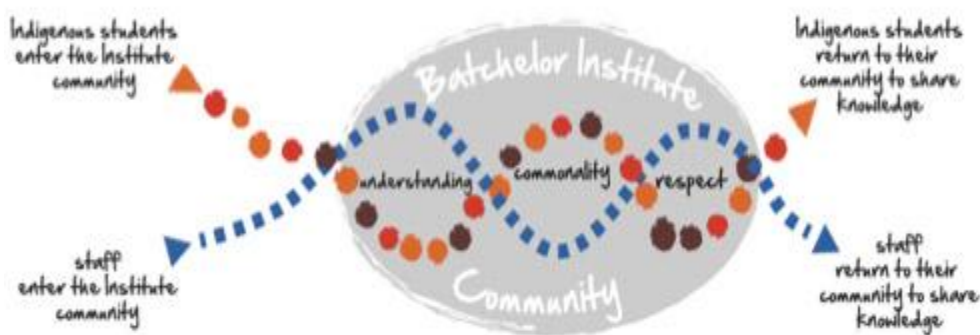
- 1) **Aboriginal Both-Ways Thinking.** Respecting and listening to each other, building relationships, *both* person-oriented and information-oriented, including context.
- 2) **Computational Thinking.** Naming and giving something more than one name, planning and scheduling under uncertainty, approximating, separating concerns, modelling, thinking at more than one level.



Presentation slide from the Report of the Early Childhood Workforce Capacity Project, Batchelor Institute of Tertiary Education and Charles Sturt University.

The activities must be simple for teachers to use and easy to carry around. They must be inexpensive to create.

Each activity must be field-tested and then re-configured based on student and teacher reactions. This requires Math Camps, Enrichment sessions, Parent/Teacher nights, and many events of this nature as venues for the activities.



For an example of Both-Ways philosophy in action, see Batchelor Institute of Indigenous Tertiary and the Charles Darwin University Australian Centre for Indigenous Knowledges and Education (ACIKE). The above figure is from the ACIKE website (<http://www.cdu.edu.au/acike>) ACIKE is creating pathways to build the social, human, economic and identity capital of Indigenous peoples across Australia.

Graduates of their partner, Batchelor Institute of Tertiary Indigenous Education (www.batchelor.edu.au):

- hold a both-ways philosophy in lifelong learning and professional practice have self confidence and a strong sense of identity
- value learning, critical analysis, creativity and Indigenous scholarship
- be a strategic thinker who can make and implement decisions
- appreciate, value and operate in culturally and intellectually diverse environments
- work professionally and ethically, independently or with others
- accept individual and community responsibility and obligations.
- the Australian Centre for Indigenous Knowledges and Education (ACIKE) will provide pathways to build the social, human, economic and identity capital of Indigenous peoples across Australia.

The modern philosophy of computational thinking and the Both-Ways Thinking philosophy is incorporated into the activities of the project.

1.3 Computer Science Unplugged – style activities

The following quote comes from an email from Professor of Computer Science Ulrike Stege, Department Chair and Professor of Computer Science at University of Victoria, Canada.

Unplugged - like activities are ideal for a professional development program for K-6. In elementary school, often computer science and technology are not existent in any form. Using fancy technological devices for teachers at that level is a challenge and therefore uncommon. Unplugged activities allow the teachers to introduce concepts from Mathematics and Computer Science that are used in everyday technology in a way that is technology free. It is not commonly understood by teachers that the material is indeed approachable, fun and interactive and at the same time covers and enforces many of the learning outcomes required at these grade levels.

Computer Science Unplugged events have contributed to vibrant, inclusive, supportive and strong school communities (see, for example, the video about Roberta MacDonald, school Principal in Victoria, BC, Canada. http://www.globalnational.com/video/index.html?v=m_S0uCWU743U3mfsXRzVEf3UNcqD7HXV#stories) Activities are active, using whole-body movement, very healthy way to learn. The math is told as story, and gives an alternate route into math for disadvantaged children or those who have not been math-successful.

1.4 Examples of how to incorporate Aboriginal story in computer activity

We report several successful directions for integrating Culture-Story and Mathematics.

- Direction (1) Choose a cultural story and embed mathematics into the story. A cultural story such as “Wirroowaa white clay and the giant kangaroos” is an example. It can introduce cryptography as Wirroowaa cover himself in white clay to camouflage, so he is encrypted and the giant kangaroos cannot see him. This is suggested by Vladimir Estivill-Castro, who found the story on http://austhrutime.com/giant_kangaroos_dreamtime.htm

- Direction (2) Choose a mathematical topic and relate the mathematics to a known cultural story. An example is the mathematical topic of graph colouring. Relate the mathematics to a known cultural story, such as story of the Rainbow Serpent. This example will be discussed below.

Example 1: Graph Coloring and Rainbow Serpent

The computer science problem called Graph Colouring has important applications in scheduling. For example making sure every student is scheduled for exams with no conflicts, or all resources are efficiently scheduled. A graph is a network of dots (also called *vertices*) and lines connecting the dots. A graph is coloured *properly* if no two adjacent vertices receive the same colour. That is, if two dots are connected by a line, then they cannot both be colored blue. The vertices might represent jobs. The colours are the timeslots A line between two vertices indicates a conflict. Two jobs cannot be assigned the same timeslot or else they will be in conflict (both rely on a shared resource, for example).

Colouring a graph leads us to a Rainbow Serpent story. The snake has colourful stripes like a rainbow. Like a rainbow, no two colours are repeated (i.e., no two adjacent stripes have the same colour). Rainbow Serpent likes to be present and observe everything, but remain hidden. Sometimes the Rainbow Serpent will surface to talk to the people and teach them. The vertices on the graph represent places where the snake might be. If two adjacent vertices are coloured the same, then we know the snake is *not* there. In order to find Rainbow Serpent, look for where colours are not repeated.

NEW RESOURCE: WWW.CSMATHS.ORG



by Mike Fellows and Frances Rosamond

Colouring a graph properly (no adjacent vertices can receive the same colour) is important in scheduling (classrooms, jobs, exams, resources).

NEW ACTIVITIES

**START WITH MATH –
CONNECT TO
CULTURE AND STORY**

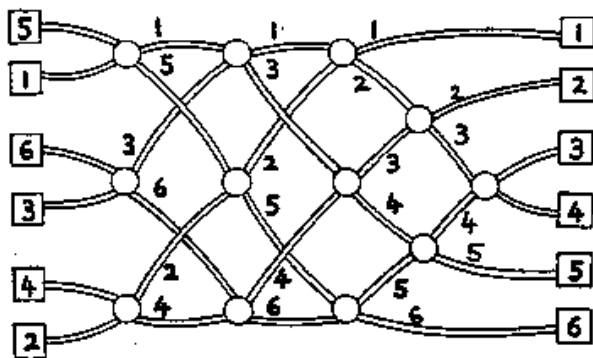
**START WITH STORY---
CONNECT TO MATH**

Screen Shot of
CSMaths.org
website

Example 2: The Sorting Network

In this example, we took a tried-and-true activity from *Computer Science Unplugged* and adapted it to Aboriginal story. For those who are not familiar with the sorting network, it is described here.

The sorting network is an example of a parallel algorithm. It is constructed on a tarpaulin with coloured tape and aluminium pie-pans as comparator nodes. It is ideal for illustrating the concept of an algorithm. A schematic of the sorting network is shown in the figure below. Values flow through the network from left to right. They are mixed up on the left, but come out on the right in order. For example, the six values on the left from top down in the figure are 5, 1, 6, 3, 4, 2. At each comparator node of the network (circle), two values enter from the left and exit to the right, with (by agreement) the larger value exiting below the smaller value, both becoming inputs for the next comparison. Notice that at the beginning, three sets of values are being compared simultaneously (in parallel).



The topic of Sorting Networks are generally taught in beginning graduate courses at university.

After much experimentation with string, spray paint and other ideas, durable and beautiful sorting networks using coloured tape and aluminum pie pans can be built reasonably cheaply and easily on blue tarpaulin (the type used for covering a car or boat). These are also lightweight and wear well.

Sorting networks work well outdoors. To activate the Sorting Network, children walk along paths made with coloured tape. Each child carries a value (such as a piece of paper with a whole number written on it). They meet two at a time at comparator nodes where they must decide which of the values they are carrying is larger, or smaller. Sorting can be done on anything that can be put in order: numbers, fractions, distances of planets from the sun, lengths, ages, brightness of colours, even chemical weights.

Teachers use the Sorting Network for lessons in history, social science, music and other subjects as well as mathematics. This is an ICT activity that demonstrates how computational thinking can be incorporated into other subjects. It embodies 21st Century competencies (as in the Singapore model).

The children walk along the tape paths on the network. They meet two at a time at a comparator node. They compare the values that they are holding (say, each have a sheet of paper with a fraction written on it) and exit the node, taking separate paths towards the next comparator. Sometimes, the paths cross. Almost always, we have to start again because some children have little understanding of maps or how to follow a path. Individuals must

have patience to wait at a comparator node until they are joined by someone else so that they can compare their values. No single individual can progress alone.



Meeting, greeting and comparing on the Sorting Network

Progress can take awhile if some couples further back cannot reach agreement—often agreement is made with the help of mates surrounding the tarp. Finally, it is understood that nobody wins alone; all win together as the sorting resolves the different values into a clear order. Six children lined up on one end of a tarp facing six goals on the other is an invitation to race to the other end. The sorting network, however, is a model of cooperative learning, more of a dance or a series of conversations than a race. To emphasize the repetitive algorithmic nature of the sorting network, children entering a node are asked to greet each other before comparing values.

The sorting network algorithm is thus:

Input: Six children holding values

1. Walk forward along the path
2. Enter a comparator node
3. Greet the person there (if nobody is there, wait)
4. Compare values
5. Exit the comparator node (in the agreed upon directions, —Larger value towards the school, smaller towards the trees, for example).
6. Repeat (Walk, Enter, Greet, Compare, Exit)

Output: Values are sorted in order

When the children reach the far end of the sorting network, they often spontaneously try to use the sorting network in reverse. This doesn't work, and many questions are raised by

teachers and children. Can a sorting network be designed that works in both directions? Except for putting two sorting networks back-to-back, the answer to this question is not known. What is the minimum number of comparisons for a given size input? Is there only one unique way to design a sorting network with n inputs?

Another topic of discussion is what sorts of activities can/cannot be done in parallel—digging a hole? Driving from Alice to Darwin? Some teachers keep the net permanently on the classroom floor, using it for lessons in history, social science and other subjects as well as mathematics.

Wondering if they were really learning anything, or just having a lot of fun, at one workshop we asked a group of six-year olds to design a three-input sorting network. One small group figured out all the permutations of three numbers that would have to be checked (to see if they came out in order), and they went around the room offering to check the other children's networks. In other words, they had learned that a correctly sorted output must result from any permutation of the input.

The sorting network offers an experience of an algorithm through whole body movement, turning abstract ideas of computer science into actions that become part of the child's physical memory. Through educational kinesiology we've learned that certain physical movements help strengthen connections between the two hemispheres of the brain, thus aiding the process of learning (see Aigen 06). The manifestation of parallel computing on the sorting tarp incorporates:

- Contemporary mathematics
- Social and cooperative learning
- Engagement of multiple senses
- Interdisciplinary facts and concepts

Using the Sorting Network with Aboriginal children

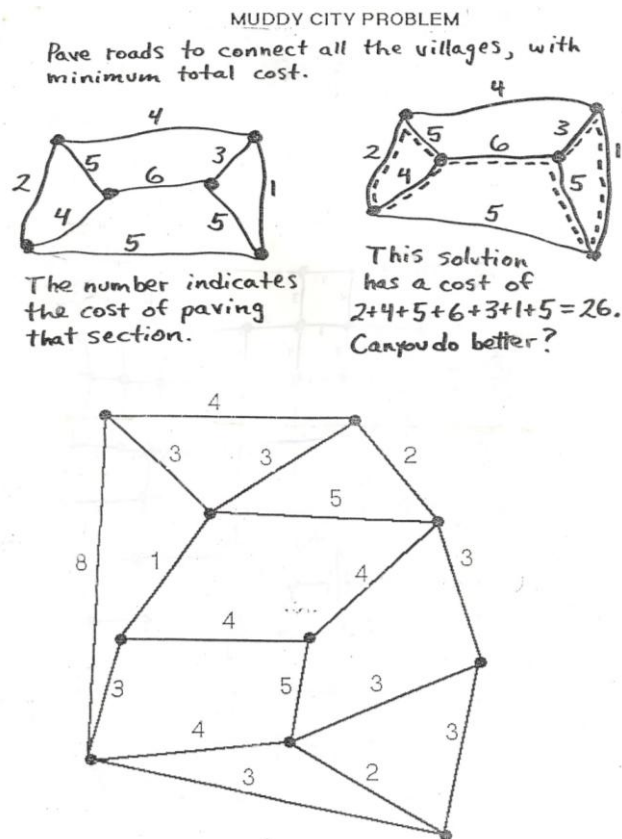
What follows is a report of an anecdotal experience. Having been told that colour is very important in Aboriginal culture, we used Aboriginal colours for the tape paths and around the comparator nodes on the sorting network. In the several times that we have used this sorting tarp with Aboriginal children, one can almost observe them relaxing.

We met Erika Pickworth, a House Parent for ten Aboriginal boys, and invited her to bring the boys to the Math on the Green evening. She agreed, with the warning that the boys might be too shy to participate in any of the activities. She advised us not to press them, as they might become very shy, and then all turn their backs.

They came to the Sorting Network and seemed attracted by the traditional colours. Mike Fellows presented it in terms of a giant *walk-about* and used phrases like “walk along the trail to the next camp,” instead of “walk along the tape to the next comparator node”. Any apprehension seemed to disappear and the boys joined right in, and then participated in other of the activities.

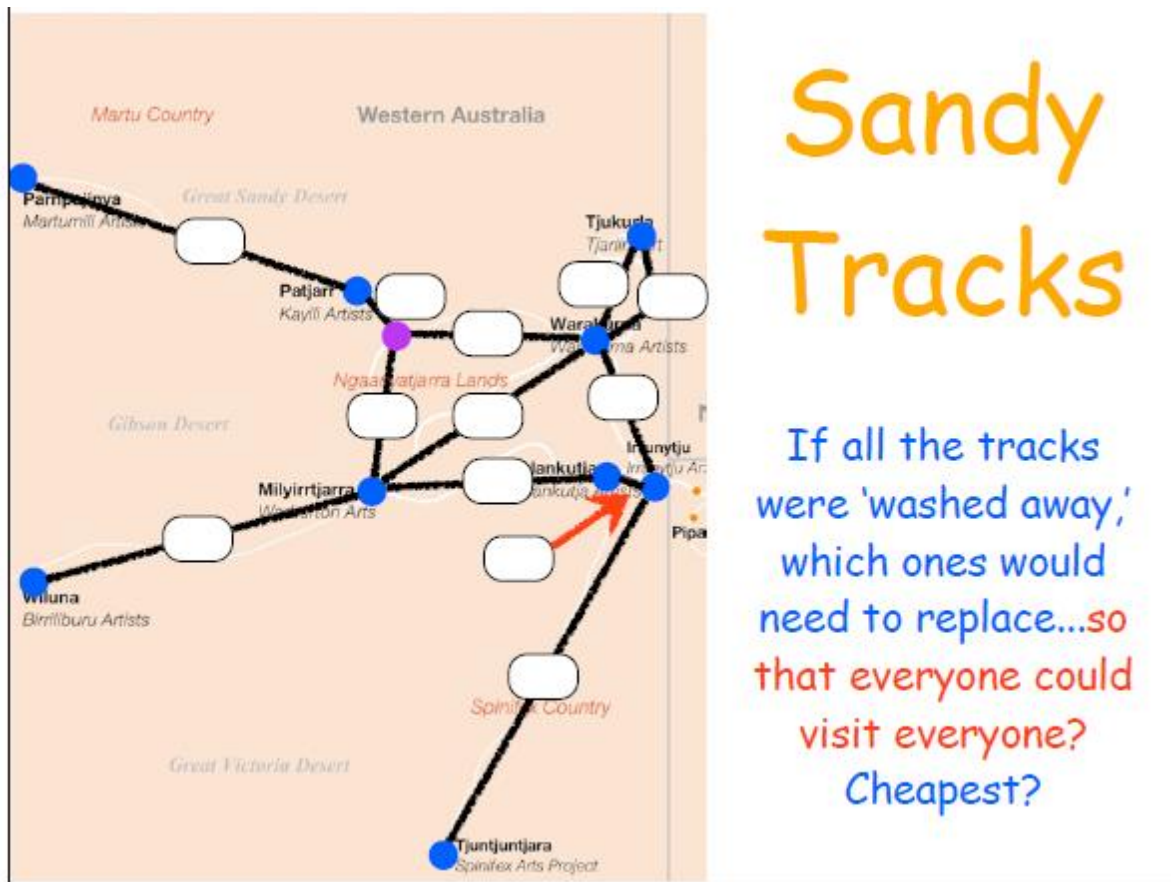
- **Direction (3) Relate mathematics and the Aboriginal environment**

Project Team member Matt Skoss, a teacher in Alice Springs, took activities to Tjuntjuntjara School, probably the *most remote school* in all of Australia. He introduced what in the *Unplugged* literature is called the “Muddy City” problem. An example is in the slide below.



In the handout of muddy city, dots represent houses and lines represent muddy roads. The numbers represent the cost to pave each road. We want to go from any house to any other house on a paved road. Which roads should be paved to accomplish this at minimum cost? A complete description of this problem can be found in the book, *Computer Science Unplugged*, or in the article by Rosamond, 2011. Children never seem concerned about the abstraction of a dot representing a house, or that shorter lengths may cost more. Most children find a fast algorithm for this problem which is to pave the cheapest roads first, and to never pave in a cycle.

The powerful aspect of what Matt is doing is that he wants *students to take creative ownership of the problem*. He doesn't want students, or teachers, to just use stuff “off the shelf.”



The slide above is from Matt Skoss's Tjuntjuntjara slideshow. The blank bubbles were to allow for some *local relativity to negotiate the 'cost' of each segment of road*. Skoss was also modelling how to build up an activity from a map.

These three ideas: (1) start with a known culture story and bring it into the mathematics content, (2) start with the mathematics and add into it a culture story, and (3) find ways for the students to take creative ownership, are being used to create new activities, and to extend current ones.

Taking activities to remote Aboriginal schools.

Part of the funding from ALTA, was to take the activities out to remote Aboriginal schools. Some of the remote school activities are the following:

Maths Camp at Ti Tree (200 km north of Alice Springs)

70 children (and 20 staff) from Year 5 to 12 participated on this camp on 9-11 August 2013. Students were exposed to a large format Sorting Network as part of the 'ice-breaker' activities on the Friday evening. One of the more inquiring students immediately tried to create a sorting network for 8 and 10 items, based on the physical experience of using the 6 item version on the tarpaulin. Also participating was 15 teachers, observing the methodology of using a large format sorting network with students of a wide range of ages, and from broad school settings, including three remote Indigenous schools (Ntaria, Arlparra, Ti Tree), Tennant Creek Primary School and representation from Government, Catholic and

Independent schools in Alice Springs. A visiting Churchill Fellowship scholar from the UK and a visiting Maths Consultant from South Australia also participated, and said they were keen to make a sorting network on their return home.

Berry Springs Primary School (60 km south of Darwin)

As part of a Maths professional learning day, a large format sorting network was modelled to Berry Springs staff (10 staff), teaching from Early Childhood to Year 6 (11 March 2014). About 150 students attend this school. On returning on 28 April 2014, one teacher (Year 4/5) had sourced the materials and made her own sorting network based on photos taken during the professional learning day in March. She used it on a daily basis with her students. When asked what the motivation to use it was, she cited:

- the opportunity to see rules and procedures being applied to language (sorting words alphabetically)
- bringing physical activity into a Maths lesson
- the opportunity to use the sorting network to challenge students to compare whole numbers, fractions in different forms (ie. pictorial, improper, mixed), decimals, and fractions with decimals

Tjuntjuntjara Remote Community School (held at Yulara, 450 km south-west of Alice Springs)

As part of a professional learning day on 1-2 July 2014, a large format sorting network was modelled to Tjuntjuntjara staff (4 staff plus one roving district teacher), teaching from Early Childhood to Year 6 (11 March 2014). About 40 students attend this school. Tjuntjuntjara would be a contender for the most remote school in Australia. Staff, along with their Principal expressed their interest in painting up a permanent sorting network on a paved area, so they can use it at any time. Also in this workshop, I adapted the Muddy Roads problem to a context relevant for this school, initially as a way of engaging the Indigenous para-professional staff (assistant teachers) with some Western Mathematics intersecting with their region, using the road network between Western Desert Art Centres as the vehicle. Unfortunately, funeral obligations prevented their attendance at the workshop. As part of the professional learning, the journey of taking an existing resources (map of art centres) to make it into an interactive resource to explore an important computer science problem was modelled. This included ‘negotiating’ with a knowledgeable audience about the nominal ‘travel time’ as opposed to distance for each road segment. This process helped them to ‘enter the problem’ in a way that connected with their world.

Two more Maths Enrichment Camps will be held in August: 8-10 August at Batchelor Area School, 22-24 August at Ti Tree School. A range of Computer Science Unplugged activities will be explored during this camp.

2 Creative mathematical sciences communication as a respectable research area.

Mathematicians must be involved in describing and identifying the unknown problems of the field, and the fundamental or cutting edge ideas. A challenge is to encourage computer scientists to think about ways to share their cutting-edge, latest ideas with children. Professional mathematicians and computer scientists rarely engage in outreach, especially for

primary school, because they, and their colleagues, do not see it as research. Outreach is usually not considered research by computer science departments or peers, is seldom rewarded and sometimes even looked down upon. Therefore, this project sought to create ways to encourage computer scientists to engage in outreach.

There have been some honours designed to acknowledge the value of computer science outreach, but few. A prestigious award is the ABZ ETH International Medal of Honour in Computer Science Communication. The award was established at ETH Zurich by Professor Dr. Juraj Hromkovic. The award was given to Tim Bell and Michael Fellows, co-authors with Ian Witten (Watago University, NZ) for their book, *Computer Science Unplugged!*.

ABZ ETH INTERNATIONAL MEDAL OF HONOR IN COMPUTER SCIENCE EDUCATION



TIM BELL



MIKE FELLOWS

- European Association of Theoretical Computer Science (EATCS) inaugural Fellow 2014
- THIS IS MEGA-Mathematics!

Slide from presentation
at ACDICT meeting
9 May 2014.

At ETH, Zurich, Professor Dr. Juraj Hromkovic has established the International Medal of Honor in Computer Science Education, which was awarded to Tim Bell (University of Canterbury, NZ) and to Michael Fellows (Charles Darwin University) for their work in creating *Computer Science Unplugged*.

Of great importance, is that interaction with children should return *new research ideas* to the mathematician, although there have been only a small number of examples. Fellows has described a new research idea for Game Chromatic Number on Planar Graphs stemming from interacting with children. Also, Fellows, together with Neal Koblitz (inventor of elliptic curve cryptography) developed the Kid Krypto activities in *Computer Science Unplugged*. A year later, in reviewing their activity, they used their work with children to forge a new *adult* crypto system, which is now a vibrant research area called “Polly Cracker.” Outreach must not be considered a gratuitous, “feel-good” exercise for the researcher. The researcher must be on the lookout for *new ideas* stemming from the interaction.

The paper, “Computer SCIENCE and Mathematics in the Elementary Schools” by Mike Fellows, is essentially a manifesto for this conference.

- Elementary school students deserve to experience profound and imaginative mathematical ideas. Such ideas shouldn't be reserved for graduate students.
- Open unsolved problems are the creative drivers for mathematical activity, but children are taught a version of mathematics based almost entirely on correct answers.
- Mathematics itself is an “interdisciplinary powerhouse.” The pursuit of mathematical ideas will open doorways and raise interesting questions in the sciences and humanities.

Mathematics popularization is a research area of basic interest. Exciting mathematical ideas will not find their way to children and their teachers without an effort on the part of mathematicians to communicate about them in accessible ways.

It is quite uncommon for a world class research scientist also to be heavily involved in popularizing basic principles in their discipline to K-12 children. Mike Fellows, an Australian Professorial Fellow and Professor of Computer Science, is one of these rare scientists, and one of the organizers of the conference.

In the 1980s, Fellows started a project called MEGA-Math, with funding from the Computer Applications and Research Group at Los Alamos National Laboratory (US). His plan was to develop materials based around modern research in computer science and mathematics and have these materials used to make early education more exciting and engaging. Mike attributes his early popularizing efforts to volunteering in the elementary classrooms of his children at Apple Blossom Family School in Moscow, Idaho. Mike recalls hurrying from his job at the university to the primary school. He had just been teaching a topic on sorting in a graduate class, and decided to teach the same topic to the children. It was a huge success. MEGA-Math ultimately led to *Computer Science Unplugged!* co-authored by Tim Bell, Mike Fellows and Ian Witten. Tim and Mike were Keynote speakers at the conference.

In the following sections, the progress made on the conference series, journal and master's degree are described.

2.1 International Conference Series in Creative Mathematical Sciences Communication

Most computer scientists and professionals recognize the importance of a conference series. A conference brings the latest, most cutting-edge and most interesting ideas to the research community involved. The repetition inherent in a conference series, either an annual or other regularly scheduled conference, brings continuity. This is useful for keeping up momentum and encouragement. Continuity also means that researchers get to know one another and then begin collaboration and exchange of ideas. Thus, a conference series seemed to be the logical first approach for establishing a new research area in creative mathematical sciences communication. We began to gather names of computer scientists who we knew would be interested, and to organize a conference.

The first International Conference in Creative Mathematical Sciences Communication was held at Charles Darwin University from Friday 2 August to Saturday 10 August. The conference activities are described below, and flyers are in the Appendices. The website for the conference is www.cdu.edu.au/conference/csmaths.

The conference was successful in exactly the ways hoped for. Scientists and practitioners were enthusiastic in wanting a second conference, and a conference series.

The second International Conference in Creative Mathematical Sciences Communication will be held at the Institute for Mathematical Sciences in Chennai, India (IMSC) from 9 – 12 December 2014.

The third conference will likely be at ETH-Zurich.

The conference will co-locate with India's premier computer science conference, Foundations of Software Technology and Theoretical Computer Science (FSTTCS) in order to help with research travel. For example, scheduling a Parameterized Complexity research workshop for the two days immediately prior to the Darwin conference allowed some researchers to come for the research workshop and stay on afterwards for the Communications conference.

Recommendation: Schedule a scientific research meeting in conjunction with outreach workshops in order to facilitate researcher travel.

2.11 Conference Events

The agenda for the workshop became quite broad in order to serve researchers, teachers, and students. These constituents were served by having several conference events. The conference was multifaceted, with constituents of different kinds, having different kinds of discussions. This was complicated to arrange, but exhilarating to all. The conference schedule and description of events, presenters, goals and aims are all on the conference website at www.cdu.edu.au/conference/csmaths.

1. PRESENTATION SESSIONS at CDU. The computer scientists who delivered presentations at the conference are at the forefront in their scientific research. They know the frontiers of the field, and the mathematical thinking strategies and competencies needed for the 21st Century. Additionally, each is recognized for creative maths outreach activities.

Scientists included Tim Bell (Univ of Canterbury) who with CDU Professor Michael Fellows, Australian Professorial Fellow wrote *Computer Science Unplugged!*, a collection of award-winning hands-on computer maths activities used around the world (www.csunplugged.org). Mike also authored *This is MEGA-Mathematics* (www.c3.lanl.gov/mega-math).

Others computer science researchers included Professor R. Ramanujam (Chennai Institute of Mathematical Science), editor of the longest running Tamil Nadu science magazine for children, and professors Michael Christie and Chris Matthews, (Griffith University) a Noonuccal man from Minjerribah (Stradbroke Island) who uses computer maths in environmental science. Also speaking were computer science professors Vladimir Estivill-Castro (Griffith University), Hon-Wai Leong (University of Singapore), Elena Prieto (University of Newcastle, AU) and Noy Rotbart, computer science PhD student from University of Copenhagen.

Robogals (founded by Marita Cheng, who won the Young Australian of the Year Award for the now global outreach program) was represented by the current CEO, Nicole Brown. Nicole is very keen about the Robogals program. **As a result of the conference, Nicole is able to bring the Robogals program to Oman.** Fellows and Rosamond were recently in Oman visiting computer scientist Professor Rudolf Fleischer, who has come to Australia several times to work on parameterized complexity. Professor Fleischer is Department Chair at Oman Technical University. The conference provided Nicole the contacts she needed.

Teacher Leaders participating in the conference were the President of the Northern Territory Mathematics Association Matt Skoss (Alice Springs), teacher of the year award winner Brett Stephenson (Tasmania), and Geri Lorway, President of Thinking 101, teacher trainer from Alberta who has many Canadian First Nations schools as clients, and others.



Tim Bell's session on Representing Data

2. MATHEMATICS and ART. 'Math across the curriculum' included a session on art led by the owners and artists of The Learning Connexion, the largest art academy in New Zealand. Alice Wilson Milne and Jonathan Milne attended the outback part of the conference where they led discussions on creativity and on creating activity.

As a result of the conference, the Milnes decided to develop a new degree program in creativity art and mathematics at the Learning Connexion. The program is in process of the New Zealand accreditation process.

3. MATHEMATICS and THEATRE. The demonstration was the melding of math and story through drama. The Frankfurt Town Council and the German Ministry of Culture sponsored actress and playwright Verena Specht-Ronique to come to the conference. She presented an adaptation of Hesse's *The Glass Bead Game*, previously adapted for ExperiMinta Science Center Frankfurt. Michael Fellows presented an overview of the first of his four Cowboy Melodramas About Mathematics, which included a proof of the Circular Braid Theorem on stage. The theatre event has led to collaboration between Verena and Fellows on possible further productions.

As a result of the conference, Verena applied for and received a grant from the German Federal Ministry of Education and Research. The program is called: Kultur macht stark - Bündnisse für Bildung (Culture strengthens - confederations for Education). Her project is

research maths and theatre at a school in Frankfurt with children from 10-13 once a week after school for some hours on the subject. After this phase, Verena will receive additional funds to create a play about the project.

4. MATHEMATICS and DANCE. Erik Stern, originator of the “Guys Who Dance about Math” Santa Cruz dance troupe provided a session on ‘Motion and Dance’ perfect for cross-discipline teachers of writing, athletics, science, math, VET, and music. Using activities appropriate Kinder to grad-school, Erik showed how to teach symmetry, probability and other abstract ideas using motion.

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An event of the Creative Mathematical Sciences Communication Computer Maths with Art, Story, Thinking!
 Conference Dates: 2—10 August
www.cdu.edu.au/conference/csmaths

FAMILY MATH NIGHT

MATH ON THE GREEN
FREE to the community Welcome

Bring the family for a Walkabout on the SORTING NETWORK. Play with ROBOTS, symmetry with GIANT KNOTS, the ROUTING GAME, CASINO PROBABILITY, MORE Explore outdoor Math.

PLACE: Charles Darwin University, Casuarina
 On the grassy lawn in front of Purple 12

DAY: Friday, 2 August TIME: 5:30—7:30 pm

Robotogs CEO, Nicole Brown would like to establish Chapters in Darwin and NT. Come meet Nicole.

From Kinder to graduates, interesting and vital maths for all ages

The Sorting Network in action Computer Science Unplugged! www.unplugged.org

Math With Motion and Dance ERIK STERN WORKSHOP

Teaching cross-discipline? Music, sports, writing, dance, science, VET and math?
This Is For You.

Slide from presentation at ACDICT meeting 9May 2014.

As a result of the conference, Eric and a colleague at Webber State University in the US have developed a university credit program on mathematics and dance.

5. HANDS-ON OUTDOOR MATH ACTIVITIES. The MATH on the GREEN was an opportunity for all to share their math outreach activities. It was an open-to-the-public free event held on the CDU campus. There were ten activities (see Appendix).

Some attendees reported that they came because they had heard about it on the radio.

Attendees to the Math on the Green , in addition to the presenters, were approximately 50 parents and youngsters. These included ten Aboriginal boys from a school in Palmerston.

6. BATCHELOR INSTITUTE. The visit to the Batchelor Institute of Indigenous Tertiary Education was an opportunity to interact with teachers of Aboriginals, and to share some of the conference activities. Kerry Grace, the Head of Corporate Services, gave us an introduction to the institute. Then we had discussions with five teachers about challenges of motivation, adult learning and other education issues, and issues related to computing maths.

7. WOOLLANING HOMELAND CHRISTIAN COLLEGE. There were three phases to the visit to this Aboriginal school, located beyond Litchfield National Park. Director Bron Bray escorted us to the tea room where we met and conversed with about 8 teachers. They drifted in and out as they had various duties. We then went outside where the students were having recess. We joined in the student games or just chatted with the students. After recess, we held a class for about 18 girls for about 45 minutes, and then a class for about 12 boys. The classes at the college are gender segregated. Our math classes were held outdoors on the basketball court. Students and teachers were enthusiastic, and we were all invited to return. We did return several months later and held another enrichment maths program.

8. OUTBACK ACTIVITIES. In addition to Batchelor Institute and Woollaning College, outback activities included

- Experimenting with new activities and implementations, including using silver plumbing tubing to stage knot theory and crime tape to stage routing, a variation on the Orange Game. The routing experiment took place at Mary River Park, and two strangers who were observing asked to join in! They were very interested.
- Listing of new topics for *Unplugged*, including randomness, game theory
- Exploring how to connect math and story, such as starting with math and then creating a plausible story (Rainbow Serpent example by Mike), or starting with a well-known story and connecting with math (Frog example by Vlad)
- Brainstorming on specific math concepts to implement into activities, such as induction and group theory.
- Building new relationships between math and creativity, a session led by Alice Milne
- Discussing the possibility of a series of like conferences, a math communication degree program, and a journal.

Peter Shaw pointed out that mathematicians are usually quite shy and that the time for getting to know each other in the outback was very helpful and valuable.

He also found it quite marvellous to talk openly about math communication to like-minded mathematicians, rather than as an aside during coffee which is what generally happens at a typical math/cs conference.

Attendance in the outback gradually decreased as participants returned to home duties. Transportation was provided from outback to the airport.

9. FACULTY OF ENGINEERING, SCIENCE, HEALTH AND ENVIRONMENT LEARNING AND TEACHING SEMINAR The Faculty weekly seminar on teaching and learning is on Thursday, so we were able to have one of the conference speakers give the seminar (Ramanujam). <http://us4.campaign-archive1.com/?u=1d6bbd01e157cdb055fcf788f&id=aca8b4c75f&e=6646d85fb9>
As a result of the conference, other teachers in the Faculty learned about the activities and are now including the sorting network and other activities in engineering courses at CDU.

10. PARAMETERIZED COMPLEXITY WORKSHOP ON MULTIVARIATE ALGORITHMICS This research workshop was timed for the two days prior to the Communications Conference deliberately so that scientists coming to the algorithmics workshop could stay on for the outreach conference.

11. BREAKFAST MEETING BETWEEN GOOGLE AND DARWIN IT PROFESSIONALS

A breakfast meeting was organized to introduce Sally-Ann Williams, the Google representative attending the conference to some of the IT people of Darwin. A positive result was that old friendships were reaffirmed and new collaborations among IT professionals were initiated..

2.12 Attendees

Participants heard about the conference primarily through personal invitation. The scientists had all heard about each other, but many had never met. They knew that each other had created intellectually pioneering outreach activities, but had not seen each other's activities. The list of names of Attendees totals 70, however some came for only part of the conference. The Survey provides a partial breakdown. Attendance for the above is approximately

Background of attendee	Number	Female	Male
Researcher and Academic	19	5	14
School teachers and Teacher Leaders	13	10	3
University Student including Pre-Teacher	9	5	4
High School students	11	5	6
Other Professionals	12	8	4

The intention of the conference was to initiate a global project, and this was reflected in the geographic diversity of attendees.

Attendees came from Canada, Germany, Denmark, New Zealand, United States, India, Singapore, Japan as well as Australia.

Please see the conference website www.cdu.edu.au/conference/csmaths for brief cvs.

Many people expressed their desire to attend the conference, but had other commitments. Some could not attend due to major conflicts in meetings such as MathFest 2013 and MoMath was holding its own conference.

Professor Juraj Hromkovic, ETH Zurich

Dr. Ralph Walker, National Science Foundation, USA

Dr. Judith Montgomery, Monterrey Bay Area Mathematics Teachers Coordinator

Dr. David Vogt , [UBC MAGIC Lab](#), [CrowdTrust Technologies Inc.](#)

Ms. Gretchen Villamil, Mathematics Coordinator, St. John's School, Puerto Rico

Dr. John O'Connor, Science and Engineering Challenge, University of Newcastle, AU

Dr. Ulrike Stege, University of Victoria, British Columbia

Professor Jonathan Borwein, University of Newcastle, Australian Academy of Sciences

IMAGINARY project, Berlin www.mima.museum, www.imaginary.org

Journal of Humanistic Mathematics, Claremont College, USA

All the above remain involved in the conference goals, and have expressed enthusiasm to attend a successor conference.

A selection of photos capturing the spirit of the conference was created by Jonathan Milne, The Learning Connexion: <http://www.flickr.com/photos/100606900@N06/with/9564698855/>

The conference attracted a visionary group of dedicated local and international computer and mathematical scientists, educators, teachers and students at all levels, and industry and government leaders in practical discussions about new ways of exciting interest in ICT and mathematics. Even before the conference, we received much positive feedback from a wide audience, including a letter of support from the Australian Chief Scientist Professor Ian Chubb and encouragement from Roslyn Prinsley, National Advisor.

“As discussed, we are very sorry that Ian was unable to attend the conference and that I could not come either. I am attaching a statement from Ian to insert in the satchel. I would be very interested to catch up with you to hear about the conference.”—Roslyn Prinsley, National Adviser, Maths and Science Education and Industry, Office of the Chief Scientist

“This is a wonderful initiative. Computer Science Unplugged was certainly a source of inspiration for me in preparing the Faraday Christmas Lectures.”—Christopher Bishop, Chief Research Scientist at Microsoft Research Cambridge

“We are very interested in the work of the conference and will help in any way we can.” – Alan Patterson, Chief Executive Officer of the Australian Computer Society (ACS)

“The workshop looks fascinating. Barbara and I will try to come. Do you mind if I share the manifesto with my son Andrew? He is currently working for Navitas in the education IT area.”—Lawrence Cram, Deputy Vice-Chancellor (Research), ANU

“CS Unplugged would be an ideal way for schools to make maths more relevant and engaging for Aboriginal children and could be the stimulus for some extremely worthwhile school-based project work that challenges preconceptions of mathematics and minimal expectations that are often the norm. I look forward to the conference.”—Stephen Thornton, Mathematics Teacher Leader and NT Coordinator of ‘Make It Count’

The CSIRO Scientists and Mathematicians in Schools Program in the NT Project Officer Maeli Cooper was eager to contribute to the conference and brought materials to share.

Recommendation: Share widely. Many people sincerely care and are interested in promoting the mathematical sciences or knowing more.

Announcements of the conference were made via the *Computer Science Unplugged!* website, the Parameterized Complexity Newsletter and mailing list, the FPT wiki (www.fpt.wikidot.com), the ISGEM International Study Group on Ethnomathematics, and through Caty Morris, President of the Australian Association of Mathematics Teachers (AAMT), the Australian Computer Science Society (ACS), and by the Northern Territory Department of Education.

The Mathematics Consultant for the NT Department of Education and Children’s Services, Maha Bishay, was very helpful in organizing a team of Volunteers to manage registrations

and name badges. Mathematics Teacher Leader Ester Tan arranged for students to help with the MATH on the GREEN, and to partner with high school student from Singapore Xuan Li Leong on some of the sessions.

Xuan Li, 17 years old, came from Singapore, flying alone on a plane for the first time. She attended every session.

CDU Media newspaper writer Patrick Nelson wrote articles for the local paper *NT Times* and <http://www.cdu.edu.au/newsroom/delegates-to-explore-frontiers-of-computer-maths>, and arranged an interview on ABC Radio with radio personality Liz Travaskus and Mike Fellows. Several people who attended the Friday evening Math on the Green said they heard about the event on the radio.

2.2 A new journal for this new research area.

Along with a regular conference series, a research community usually has a journal for sharing the best ideas, announcements and sharing of issues. There was discussion at the conference about the feasibility of a journal. Issues were the merits of a print journal versus website publication in terms of cost, readership, prestige, publication house and other issues. A large issue is finding/choosing an Editor and Editorial Board.

In the interim, a name has been purchased and a blog has been developed. The site is www.csmaths.org.

2.3 Master's degree program in creative mathematical sciences communication.

A research field generally has a path by which students can enter the field. Discussion is ongoing on the creation of a new, innovative Master's degree program in creative mathematical sciences communication, to be offered by an international partnership or consortium of universities. There has also been investigation of MOOCS and of the Certificate program offered by Robogals. No specific decisions have been reached at this time, but the ideas will be discussed again at the Chennai conference in December.

3 Dissemination of the ideas

Dissemination has taken several forms.

- The conference was filmed and live-streamed on YouTube. The link for the YouTube channel is

<http://www.youtube.com/channel/UCE5Izk40f7Nw1jlk52SrMnA>

or

math.communication.darwin.live

There have been over 800 viewers from over 50 countries.

PhD students Siva Kamalnadh Vallabhaneni and Kai Wang, together with post doc Mahdi Parsa did the live-streaming and uploading to YouTube (a first for them all!). Files have been saved and will be edited for future use. We anticipate adding new videos to the channel. The Mathematics Theatre will be added once copyright permission from various German writers has been obtained.

- The domain name www.csmaths.org has been reserved for ongoing community building via a website.
- A blog has been created at www.csmaths.org and blog editors are being chosen.
- The List of Interested people is continually updated and they are provided updates on activities and events.
- Several papers are being prepared for publication by the project leaders and team members.
- Team members, including Matt Skoss will present at the November Mathematics conference in Melbourne.

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Computational thinking is a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science. To flourish in today's world, computational thinking has to be a fundamental part of the way people think and understand the world. Center for Computational Thinking, Carnegie-Mellon (<http://www.cs.cmu.edu/~CompThink/>).
(<http://www.cs.cmu.edu/afs/cs/usr/wing/www/publications/Wing06.pdf>) .

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- A: CORRESPONDENCE
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APPENDIX A. CORRESPONDENCE

In addition to survey feedback, the following taken from email correspondence within the first two weeks following the conference indicates outcomes and collaborations.

Jam wrote that he will now use *“more drama street theatre and songs for science popularization, exploring these media seriously for science communication and forming new means of collaboration is an achievement. I have discussed ideas for further exploration with both Erik Stern (using physical transitions to talk of transformations in groups) and Verena (dramatizing the fundamental theorem of algebra.”*

Erik is collaborating with Matt, Brett and Jam. Erik wrote that he *“already has concrete directions: 1. Direct dissemination together with Brett and Jam and Matt and Chris, I plan to conduct direct research about the methodologies and methods which will be tested in white and Aboriginal schools. 2. I will be exploring new math ideas with Mike and Jam as fodder for working into dance and teaching.”*

Matt Skoss wrote *“I am very grateful for being able to be part of the conference. It would rate as one of the most inspiring experiences I've ever had.”*

Matt and Ian Roberts held a Middle School Maths Workshop immediately after the conference and used many of the ideas. On the 15 August, barely after the conference, Matt Skoss wrote that he has *already made a couple of tarpaulins, and used them at our Maths Enrichment Camp (60 kids, 25 teachers), in my classroom (my Year 7 kids helped me make two networks) and again last night at our school open house.*

Matt's email continues: *Last night the special Education people got very excited about the Muddy Roads problem (especially the big version of it), and have booked me in for a session with their kids. My very low level Year 7's have really surprised me with how they've taken to binary numbers...*

I had a Churchill Fellowship winner from the U come on the Maths Enrichment Camp. He was just raving about the activities, and how accessible, but deep they were.

Matt also reports: *We are intending to have an MTANT MathsMeet Conference in Darwin on Sat 12 Oct, perhaps spilling over into Sunday. I was going to work people through a few CS Unplugged tasks, as a way of sharing what I learnt at your conference.*

Brett Stephenson wrote that he has presented conference ideas to his pre-service class and *they were riveted and fully engaged.*

Ferdi Kleisch and Neil Williams have transformed an entire floor of the CDU engineering building into a working display of various sorting networks and have already started integrating the activities into their courses.

A CDU undergraduate music and mathematics major, Kathryn Pickworth was so impressed on the first afternoon, that she tried to rearrange all her weekend music commitments in order to attend as much as the conference as she could. She said the *conference changed her life.*

Collaboration between the participants was an outcome, especially during the outback which was designed to allow relaxed time for scientists to get to know each other informally and have plenty of time for informal engagement. Tim Bell wrote, *"For me collaborations will be a lasting outcome, with potential collaborations with at least 6 people who were there."*

Vladimir Estivill-Castro has arranged a September stop-over in Singapore on his way to Barcelona in order to collaborate with Leong Hon-Wai.

Richard Buckland, UNSW creator of Australian MOOCs in computer science wrote to ask us to visit at UNSW and collaborate.

Woolanin College requested that we return to give another workshop. Mike and Fran have committed to returning. Mike and Fran have also been invited to present workshops at schools on the Tiwi islands. Paperback Woman from the Larakea tribe Lenore Dembski will coordinate Aboriginal workshops.

APPENDIX B. FULL SURVEY FEEDBACK DATA (30 RESPONSES)

Google Docs was used to create the survey.

Question 1. How strongly do you agree or disagree with the following:

Overall, I found the conference to be worthwhile

Strongly Agree	22 73%
Agree	8 27%

Neither Agree nor Disagree 0 0%
 Disagree 0 0%
 Strongly Disagree 0 0%

An important aspect of the conference was meeting like-minded thinkers

Strongly Agree 18 60%
 Agree 11 37%
 Neither Agree nor Disagree 0 0%
 Disagree 1 3%
 Strongly Disagree 0 0%

This conference has helped me grow professionally

Strongly Agree 17 57%
 Agree 8 27%
 Neither Agree nor Disagree 4 13%
 Disagree 1 3%
 Strongly Disagree 0 0%

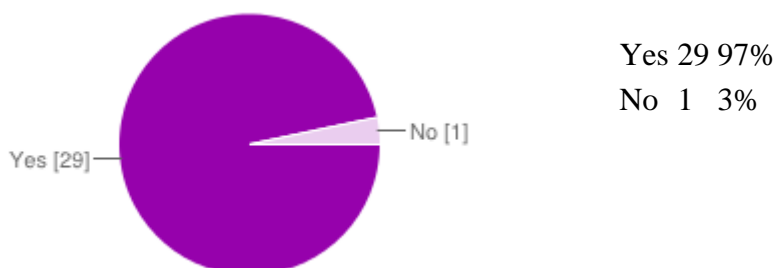
The sessions lived up to expectations

Strongly Agree 14 47%
 Agree 12 40%
 Neither Agree nor Disagree 4 13%
 Disagree 0 0%
 Strongly Disagree 0 0%

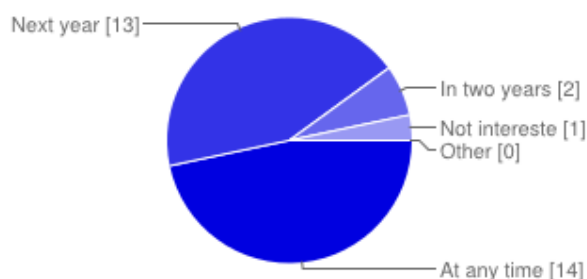
I will use ideas from the conference in my teaching and future outreach efforts.

Strongly Agree 18 60%
 Agree 8 27%
 Neither Agree nor Disagree 3 10%
 Disagree 1 3%
 Strongly Disagree 0 0%

Question 2. Would you recommend this conference to colleagues?



Question 3. Would you attend a similar conference (if your personal time/finances allowed) and it it were offered



At any time	14	47%
Next year	13	43%
In two years	2	7%
Not interested	1	3%
Other	0	0%

Question 4. How were the social aspects of the conference?

Interesting The coffee breaks were cool - didn't do any of the other things as I live in Darwin and have done most already Very good - relaxed and appropriate catering was excellent; excursions were magnificent. Longer stays in fewer venues would allow time for more discussions. Good Great! Independently purchased food was really expensive though... Fantastic, well paced, nice home-made touch. It was enjoyable, and a good chance to interact with other conference participants. Excellent; coffees and meals were homemade and of great quality; excursions were amazing. I enjoyed the time to discuss with colleagues and new people. So nice to be able to talk about math education issues freely, and not only pure mathematics. good As I got so much from talking to like minded people perhaps a little more time during the conference talks to speak might have been nice. But there was already so much to cover and I would not have wanted to leave anything out either. As I had no idea what to expect I was not disappointed Breaks were not long enough. Food was not substantial enough. Excursions were overpriced and not needed. Would have been better to give participants more free time to connect with each other. Very good. Always had the chance to have interesting and useful talks to various people about the conference and other themes of interest. Sometimes the breaks were a little short, but one could always find time to discuss. The excursions were especially helpful to actually meet. They were good for a chance to meet other people who attend. However I feel we were restricted on the campus somewhat and would have benefited with more information about getting into town/etc. The meals were great. Excellent - well organised and casual, allowing for further networking. Very good The excursion to Crocodylus park was great! Had a lot of fun. I really enjoyed speaking with fellow attendees. It was so very good to meet everybody and to exchange informations and to grow in knowledge. Everybody was happy to share and work together. Very positive conference for me. Catering etc was excellent. The excursions were all good and some were brilliant. Northern Territory is astounding at this time of year. The landscape put human life (and mathematics) into perspective. very enjoyable, especially the hospitality from lola and

annie. Perhaps, one thing to do might be to have organized small group, focused discussions on the goals. That way, the participants get to really think hard about those issues and also cross-fertilize their ideas during these focused discussions.

Question 5. Integrating math across the curriculum is an aspect of "21st Century Competencies". The conference explored areas of Art, Theatre, and Dance. What other areas would you like to see explored?

Good question. Possibly music, games and interactive ways of exploring. I like more Aboriginal teaching for Science and Maths as their world view is so very different to the Western view. creativity in its own right, as a part of 21st competencies i think the relation between math and computing with the natural sciences needs greater exploration. we did have a teeny discussion involving chemistry but overall, this is an important area. i'd also like greater exploration of storytelling and music. Sport, Humanities based subjects Meaningful assessment. Perhaps some new software that intersects with conference themes. Eg. Turtle Art, Scratch, etc. Music, Sports There should be more teachers who can actually talk about how to integrate this into curriculum in a sustainable way. I would like to explore theatre more, but music would be an area that should have many possible ways of integrating with math. I believe these areas were important, but I would have liked a stronger focus on just what different people are doing around the world, not just looking at the curriculum itself. Music, Physical and Oral Story Telling, Understanding Reasoning and encouraging it in children Firstly I would like to thank you and the presenters from these areas for including this. I got a lot out of this and have already used it in my classes. Some obvious next area would be music and sport. Jam has some techniques he uses for Cricket. other areas of science History, geography, ... all subjects should have math integrated into them. Especially math vocabulary. I imagine many newspaper readers have difficulty with phrases such as "rate of increase has decreased." I loved all that we did Any holistic educational areas that integrate Maths It would be good to have mathematicians collaborating in advance with art/theatre/dance people so that we could tune our presentations to be more connected. The basic theme of '21st Century Competencies' could go on for the rest of the century! It's extremely important. More story telling based mathematics that can be applied in the classroom The role (or lack thereof) of these new ideas in established education. I think there were divergent opinions on whether our ideas should be integrated into the education system. This question arose tangentially many times, and is worth exploring explicitly.

Question 6. How important to you are the conference goals listed below? (Sample size 30)

Create Indigenous friendly and new math activities

Very important	20	67%
Somewhat important	10	33%
Not important to me	0	0%

Explore new outreach ideas

Very important	22	73%
Somewhat important	8	27%

Not important to me 0 0%

Explore math across the curriculum (art, dance, theatre, etc)

Very important 21 70%

Somewhat important 8 27%

Not important to me 1 3%

Explore a Master's Degree program in Creative Mathematical Sciences Communication

Very important 9 31%

Somewhat important 12 41%

Not important to me 8 28%

Create a professional journal in the area

Very important 15 50%

Somewhat important 13 43%

Not important to me 2 7%

Develop an ongoing conference series

Very important 20 67%

Somewhat important 7 23%

Not important to me 3 10%

Question 7. Comments on Goals

As a teacher I found it inspiring and encouraging to realise that others believe that maths needs a multi disciplinary approach to engage children. - Governments have woken up to the fact that they can computerise lots of measurement but they have a poor understanding of the purpose of measuring. One of the effects is to impose heavier bureaucratic control than ever before. This is bad news for inter-disciplinary interaction which necessarily requires suspension of preconceptions. The conference is potentially a significant influence in returning things to a kind of sanity - it's so rare to gather such a diverse set of highly skilled people. I hope the interaction grows and spreads! to me a very important goal is community building -- which comes through a sense of shared activity and is sustained by a sense of shared success. so each conference in this series needs to articulate goals that achieve both of these. Exploring interactive and inclusive educational pathways across all disciplines is an urgent task. Recording conference papers and debate becomes part of a growing body of knowledge. A professional journal is a focus for general discussion and research. I want this conference to impact teachers and teacher leaders and those who manage teacher materials like curriculums... I want this to impact children and students in schools, not just in outreach programs that often have their own hidden agendas... I want researchers and those outside of classrooms full of students to better understand the role of teachers, the job of teachers, the frustrations of teachers and the incredible impact they have on creating future thinkers and leaders. I would love to look at a Master degree - just have to finish the first degree..... I very

much like these goals. Since they evolved and were articulated towards the end of the conference, it will be exciting to see how they inform the structure and presentations at the next conference. I like to stay in touch and grow and help set up Maths and Science workshops and clubs in school. I was so very much inspired by Jam's work in India and love to see this her in Australia as well. I don't thing the first 2 goals were focused on enough or met. Our ultimate goal is to put these fabulous ideas into practice in schools. I have spoken to a teacher at school who it high in thew Catholic Ed working for Maths he wants to come along and set something up. He has asked for all the Material as well. The focus of the conference should move away from the idea of creating a Master's degree and focus on getting people from a variety of organisations together to share ideas and practices. Broad goals touching on many needs. Given the prevalence of Indigenous learners in our locale, this was the most pertinent from my perspective. Having seen and experienced the different approaches towards maths and ways of thinking from various knowledge expertise, I would personally also like to look more into it from an anthropological point of view. This became only clear to me throughout the conference and time time afterwards. Looking at different ways of practice, social and cultural elements, economic situations etc. I think especially when thinking about curriculum, this might lead to important facts and could contribute to the rest of the Goals. There will always be delicate tradeoff between being very broad and encompassing everyone and having more cross-breeding, cross-fertilization of ideas vs being more focused and having better integration of the people and more in-depth discussions. I think each of the three goals (Conf-series, Journal, Master degree) is itself a big topic, and if pursued will require substantial efforts and may need more "champions". I missed 2 days in front and 2 days at the back and so, my impression may NOT be the best one. But I sense that we do not yet have enough champions for all three goals. Create network of people, blog or website with material that we can use in classrooms Important to target key people in regional areas, to engage the next layer of teachers. This is a BIG, global project. Very needed!!!

Question 8. Which sessions did you attend? (Sample size 30)

Friday sessions at CDU

- Big Issues: Parallel Thinking and Sorting—Mike Fellows Option 1 21
- Enormous Science Fairs, Math in India—Jam 26
- Computer Science Unplugged—Tim Bell 25
- MATH on the GREEN—Outdoor math activities 25

Saturday sessions at CDU

- Big Issues: Unsolved Problems and Graph Colouring—Mike Fellows 23
- Australian Aboriginal Mathematics Education—Michael Christie and Chris Matthews 24
- Confidence to Solve a Riddle—Noy Rotbart 20
- Science and Engineering Challenge—Elena Prieto 24
- Crocodylus Park 15
- MATH and ART—Jonathan Milne and Alice Wilson Milne 22

Sunday sessions at CDU

- Big Issues: Network Problems and One-way Functions—Mike Fellows 21
- ALICE Programming and Robotics—Vlad Estivill-Castro 22
- 21st Century Critical Thinking—Geri Lorway 24
- MATHEMATICAL THEATRE—Verena Specht-Ronique, Mike Fellows 22

Monday sessions at CDU

- Big Issues: Kid Krypto—Mike Fellows 19
- Google's Technology for Communicating—Sally Ann Williams 22
- Robogals—Nicole Brown 23
- Zero-Knowledge Proofs—Leong Hon Wai 23
- MATH with MOTION and DANCE—Erik Stern 22

Question 9. Please comment on any of the sessions

Outstanding quality across the board. Looking forward to YouTube coverage of the few sessions that I missed. I learnt a great deal from all of the sessions. The smallish nature of the conference enabled strong collegial relationships to be built amongst all participants. Sessions that Mike Fellows and Tim Bell would rank as some of the most significant in my career...simply awesome! There were too many sessions run without practical bridges to the classroom and by people who were not focussed on long term classroom objectives. varied speakers with very different presentations. I thought the dance session was excellent Geri's session was amazing Michael christie made a lot of sense Overall, the most important point for me was to learn about the various fields all participants of the conference are involved in within their academic and professional field. Also to hear about and experience so many different ways to approach maths and how diverse and fruitful they are if strategically interconnected and thought interdisciplinary. I watched the videos for Monday - couldn't attend due to work. All sessions were great and so different; hence the enjoyment! The sessions were all engaging and insightful. However, the things covered were rather diverse. It felt like a descriptive sharing of the various efforts happening in different places, with some analysis and links between different ideas across speakers. While it was very inspiring, it feels like there could be something even more meaningful done with the group of passionate individuals all gathered in one place. But probably, as the conference progresses, it will gradually find its specific area that it wants to target and perhaps that will help bring in more analysis and inspiration which sparks off projects or movements. Some of them were absolutely fantastic. I particular Eric Stern's one in dance really opened something I had never thought of before. The only rule of thumb I suggest: no attendee should be asked to sit longer than 90 minutes without a break. Probably my favorite session were Math and Art, Mathematical Theater, Math on the Green and Math with Motion. This suprized me as originally I thought I would have preferred thinks like Google's Technology for Communicating. I didn't see all of these session live but watched some later using video streaming it was a good variety for me -- some reinforcement, some mind-stormingly new and some puzzling. Jam's presentation on Science fairs etc was a fascinating insight and very inspiring. Tim Bell's session was very hands-on and stimulating, offering teachers new approaches to sometimes poorly presented concepts. Math on the Green attracted many young participants who appeared to enjoy the activities on offer. Some young people were

involved in facilitation of activities and excelled at this. It was wonderful to see. I enjoyed the most the talks that mostly focused on the math part (and less on the education part) I loved the following sessions: Big Issues: Parallel Thinking and Sorting—Mike Fellows Option 1 • Enormous Science Fairs, Math in India—Jam • Computer Science Unplugged—Tim Bell • MATH on the GREEN—Outdoor math activities Australian Aboriginal Mathematics Education—Michael Christie and Chris Matthews MATH and ART—Jonathan Milne and Alice Wilson Milne ALICE Programming and Robotics—Vlad Estivill-Castro MATHEMATICAL THEATRE—Verena Specht-Ronique, Mike Fellows Google’s Technology for Communicating—Sally Ann Williams Robogals—Nicole Brown MATH with MOTION and DANCE—Erik Stern I particularly like Vlad's presentation -- when he built systems that really dovetail very well with some of the hands-on CS unplugged activities. Of course, Vlad's multi-faceted talent is evident. All the sessions were of very high quality; my favourite sessions include Big Issues - Mike Fellows, Computer Science Unplugged—Tim Bell, Australian Aboriginal Mathematics Education—Michael Christie and Chris Matthews, MATHEMATICAL THEATRE—Verena Specht-Ronique, Mike Fellows, Zero-Knowledge Proofs—Leong Hon Wai, and MATH with MOTION and DANCE—Erik Stern. Enjoyed them all All fab!!

Question 10. Will you be doing any of your math communication activities any differently in light of what you learned at this conference?

Validation more than new ideas i think so, especially in terms of greater usage of physical activities and use of emotional means. Yes definatly. It gave me confidence to include these activities and others discussed in my classes already. - I will incorporate as many of the new ideas seen into my pre-service classes and my college classes. Maybe not the current ones, but ideas presented have stimulated possible new activities. Using Quick Draw in classes Yes, I will use some of the activities to teach my students, while also requiring them to define and analyse the algorithms. As a leader of teachers, I will certainly implement some of the ideas presented in advising and offering feedback to teachers on their practice. Immediately worked with ideas from graph colouring, riddle solving, motion and dance ideas with 5 and 9 yr olds . I am still thinking about this. But it WILL happen. YES. I want to learn the music and motion as led by Erik. I also want to do street theatre. Yes! There is a lot to be done. One of the big plusses is that I felt even more impressed by Ian Stewart's books (especially 'What Shape is a Snowflake?' and 'Does God Play Dice?' His approach connects well with the themes of the conference. Not differently, but integrating new ideas into my curriculum Probably, the dance part (see above) Have already made up a few resources and trialled them in a variety of settings. Yes!!! Yes Absolutely. Yes, the conference has challenged me to think about more creative ways to teach math. I might use the consonant-vowel pattern for names in my icebreaker activities with kids. Definitely. For me and my work it became clear, that philosophical aspects in thinking about maths and peoples lifes are nice, but that I want too and need to go much more into the deeper mathematical thinking and real maths to show what should be shown. That is trying to make the gap between such complex maths phenomena and everyday life (like that of children or other people) smaller. This is what I learned: there are ways to show, that maths in its complexity has to do with our everyday life and can be understood in certain terms. I will do some things different and some extensions on my own work

Question 11. Have you made new collaborations through the conference?

Potentially several! Yes, various. With Mike and Jam. In finding ways to bring maths closer to the people through story telling and theatre methods as embodied and sensual experience. - many, many. I will keep in contact with the Batchelor Institute teachers and the Woolanng teachers, as well as the conference people and those in the schools in nt. We have been invited back to do workshops in Woolanng and the dates are almost set. Absolutely Yes, we initiated collaboration with several colleagues. Yes...with a strong sense of community arising from shared experiences. Not yet. But I have not contact and we have started talking about ideas with theatre yes The collaboration that was developed at this conference was outstanding. The divergent thinkers and creative mathematicians sharing ideas was refreshing. I have grown, I have learned lots and I have made connections with all conference members. Made some new and renewed some old contacts, providing avenues for future collaborations. i hope to make several. i have discussed preliminary ideas with mike, tim, vlad, erik, peter, noy, elena and verena: even if a few of these take off, it will be wonderful. The conference gave us a unique opportunity to meet up with others in different domains to discover how we link and connect. Several in depth interactions will be taken forward. We hope to connect with Jam in regard to the science fairs in India. We will introduce maths patterns in dance and music following Eric's book, and would like to develop this connection in the future. We will stay in touch with Rudiger and Marlise. Yes I have made wonderful connections. As to collaborations, it's too early to tell. Certainly there will be communication will others, and we'll see what comes. That's exciting. I have and am currently waiting on responses. Made many new diverse, but like-minded colleagues and friends, including two new young friends (Everywhere I go, I make friends with young children! I cannot explain, it just happens.). Am busy now, will will forge the collaboration once my schedule loosen up a bit. with Chris Matthews Yes.

Question 12. Please describe any future plans or projects as a result of the conference.

We are looking closely at our curricula to see where creative math approaches may fit. Will present visual network activities across the NT and at interstate conferences. Will develop my confidence in using other ideas that weren't modeled (eg. Vlad's rail sorting) and trial in a more kinaesthetic format. - Planning and working on the plays of Mike Fellows to produce and show them in germany in 2014 (and later possibly in other countries) to a wider audience. Working with Jam about various mathematical phenomena using theatre methods to convey. Possibly done in India in 2014. I spoke with some attendees who said they were interested in using my approach in their classrooms. I look forward to communicating with them and better understanding my methods by seeing them through the eyes of experienced, open-minded mathematics teachers. I will be doing my lesson plans much more hands on math plays in Germany I will be looking at ways that big ideas can be introduced creatively to mathematics classes I will implement CS unplugged more widely and teach my students some of the things I learnt Chris Matthews plans to visit TLC in the near future to observe, advise and collaborate on aspects of our multi-cultural delivery in education. Tim Bell is interested to be part of our proposed High School to Masters programme, yet to be agreed to by government. Mike and Fran will visit us in Nov for discussions regarding this conference. Working together with Google to run another type of conference, and potential to expand our organsiation around the world. Validation of projects on go and about to start not new projects Maths and Science clubs at school New ways to teach Primary students Robogirls in my school for all students to learn Computer science unplugged 2 would be fruitful. Do more sorting network activity in my university. I also want to do a large-scale ice-cream problem, maybe. 1. plans for several activities / games that involve combinatorics, distributed algorithms and automata theory. 2. exploration of activities based on randomization,

especially random walks and random graphs. 3. exploration of physical transitions in dance to study transformations in math. 4. use theatre / story telling to dramatize the fundamental theorem of algebra. Workshops at Woolaning and its sister schools. Plays on math and proof in Germany with Verena. Next conf in Chennai with Jam. Create newsletter while establishing a journal. Establishing a Certificate, as does Robogals I plan to contribute to the newsletter and to the journal once it is established; I would like to help with the Master's degree if it goes ahead with the future. Invite some of the conference presenters to NZ and generally build on the experience. Keep in touch by email, flickr etc.

Question 13. How useful/important to you were the following activities during the Outback part of the conference?

Experiments with new activities (knots, orange game, etc.)

Very useful / important	14	64%
Somewhat useful / important	4	18%
Not at all	4	18%

Discussions of new topics for Unplugged! and other activities (randomness, infinity, induction, etc.)

Very useful / important	13	59%
Somewhat useful / important	6	27%
Not at all	3	14%

Interaction with teachers at Batchelor Institute (challenges of motivation, adult education, etc.)

Very useful / important	10	53%
Somewhat useful / important	4	21%
Not at all	5	26%

Interactions with teachers at Woolaning Homeland Aboriginal Christian College

Very useful / important	6	40%
Somewhat useful / important	5	33%
Not at all	4	27%

Woolaning class with girls, with boys

Very useful / important	7	47%
Somewhat useful / important	5	33%
Not at all	3	20%

Sessions on creativity, connecting math with story

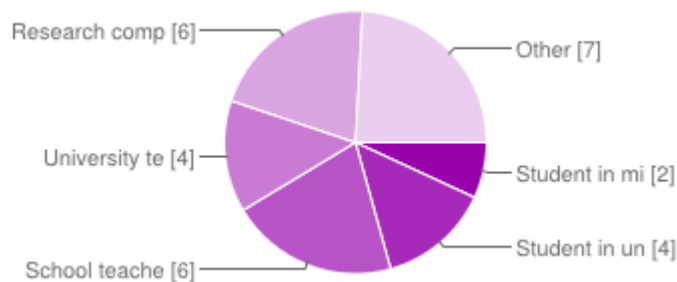
Very useful / important	10	53%
Somewhat useful / important	6	32%
Not at all	3	16%

Question 14. Please comment on any of the sessions

Thank you for organizing so many great opportunities for us in the land of NT. Interacting with educators and students in rural areas and being out doors let us get to know one another better, and enlivened discussions related to the conference. I love the open-ended nature of some of the discussions/sessions. In the future, consider designating discussion facilitators; they can be there to clarify the direction of these open-ended sessions. i'd have liked an opportunity for greater interaction with teachers at the batchelor institute and with children at the woolaning school, our time in these places was very limited. All sessions were well presented. I was particularly impressed with the Erik Stern workshop with he links between Maths and dance The working sessions were too small a part of the 4 days. The length of time spent traveling to locations in Annaburro for essentially the opportunity to go on a river cruise was a waste of time. This trip could have been completed in 2 days and in a much more organised manner. It felt more like a holiday than work. I am unclear on what some of the sessions were but answered what I thought. I wish I could have attended the outback sessions - but unfortunately I had to work. I have learned and grow so very much. I have reflected over it every time I come up with more and found that my head is just so very full of great ideas I get all the staff interested at school and will so very much enjoy the next conference. For me this all was live changing.. Anthropologically important I found the visits at the Batchelor Institute and Woolaning College. Here it became clear to me, that teaching depends so much on cultural, historical, social and economic factors and that the tracking down of those various components is quite complex and needs looking into. The experiments, games and practical sessions were very important to me because I needed to experience the practice of maths in various forms other than my own experiences at school. And how to combine it to the arts and story telling. Great to give workshops to the students at woolaning. I learned a lot talking with the teachers at both places. We firmed up the outcomes during conversations. Lots of examples of connecting math and story--very useful. Did not attend any outback component as I had to work and did not have enough advanced notice to take leave. Interaction with teacher and students at Woolaning Homeland Aboriginal Christian College as an exceptional experience; Mike and Erik did an amazing job with the children and we were all able to observe the differences in the girls' and boys' approach to new challenges. I was not able to attend the work in Batchelor and the Aboriginal Christian College unfortunately. For this reason I didn't feel in the question Didn't attend Outback sessions The games were fun! It made me think a lot about how to recognise mathematical concepts even when they are disguised under a game, and how this disguising can be used to explain concepts to peers or juniors who are intimidated by the symbols and numbers of math. The outback period was a great chance to get to know people better. This was more important (to me) than the sessions. Unfortunately I Was not able to attend any of the immediately above sessions. I wish I could have interacted with the teachers and students! (Missed it as I had to travel home early.) That would have been a really good highlight of the trip. I enjoyed very much the message passing game (distributed computing)

Participant Demographics

Please let us know your occupation



Student in middle or high school	2	7%
Student in university	4	14%
School teacher	6	21%
University teacher	4	14%
Research computer scientist or mathematician	6	21%
Other	7	24%

Regarding registration, how important was the scholarship/financial help to you?

1	12	43%
2	1	4%
3	4	14%
4	3	11%
5	8	29%

How did you learn about the conference?

by invitation from mike and fran, in discussions last year. I was fortunate to attend a workshop run by mike and Fran in 2011 at Alice Springs. Their message resonated strongly with me and their idea of a creative mathematical sciences conference was appealing. I have stayed in contact since. I got an e mail from a CDU student enrolled in Science this Semester. Email via Maths network but only a couple of weeks beforehand Direct communication with Frances. My attendance was in a support, rather than participation, capacity but did result in my being participant in sessions. From Fran's email and web page Through Fran Rosamond. Mike and Fran emailed my father (Hon Wai). Through friends of Frances and Mike Rosamond My university lecturer sent me a link Mike and Fran Note for above: I did not receive a scholarship because I assumed we had to pay but upon discussions with many others there fee was 'included'. Clarification would have been useful :) I heard about the conference through an email from Fran. It was great to make a few of the connections, however overall I'm not convinced the objectives of impacting teachers in classrooms was reached. Contact from Frances. Was contacted by conference Director. Via Fran and Mike Email blast. From emails from Fran and the Web Site Invited Personal communication with the organizers. via CDU comms.

Number of daily responses

