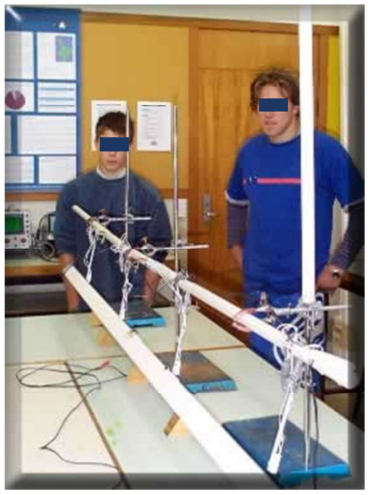
Open Polytechnic
KURATINI TUWHERA



FROM GALILEO TO LIGO

RECLAIMING THE 'MAKER SPACE' FOR SCIENCE

School of Science, Technology and Engineering, The Open Polytechnic, New Zealand

PRESENT BY MICHAEL FENTON, M.Sc., Dip. Tchg., MRSNZ

Scicon2016 keynote

I will be sharing some stories based on my experiences as a scientist, educator and science communicator.

These stories are for entertainment rather than proclaiming yet another "***new***" way to teach!

Rather, these stories are old, recalling a distant memory of the way things used to be (for me at least!), wondering why science is not perceived by many as cool or as sexy as some of the robotics/coding/3D printing people are proclaiming their subject to be.

Take what you will from these, they are meant to inspire, challenge and stimulate!

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MY BACKGROUND

- Scientist / Lecturer / Writer
- Science & Mathematics Teaching
- Registered teacher
- Research and industry experience
- Game design/coding, robotics, biology, chemistry, physics, calculus

I take a holistic view of the science disciplines as I am an expert teacher of more than one discipline but I also see science and technology as supporting the development of the other…you cant 'do' science without technology, and technology develops and progresses due to new knowledge from scientific investigations.

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www.NexusResearchGroup.com

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MY BACKGROUND

- Scientist / Lecturer / Writer
- Science & Mathematics Teaching
- Registered teacher
- Research and industry experience
- Game design/coding, robotics, biology, chemistry, physics, calculus
- Ministry of Education eLearning Fellow
- Microsoft Innovative Teacher
- 2014 DEANZ eLearning Excellence Award
- 2015 Prime Minister's Education Excellence award
- Director/consultant, Focus Consultancy Director/founder, Nexus Research

These last bullet points are only listed to indicate various professional development opportunities have also shaped my decisions about what stories to tell and what messages I believe can be taken from them.

You can read more about my teaching, research and curriculum design experiences here:

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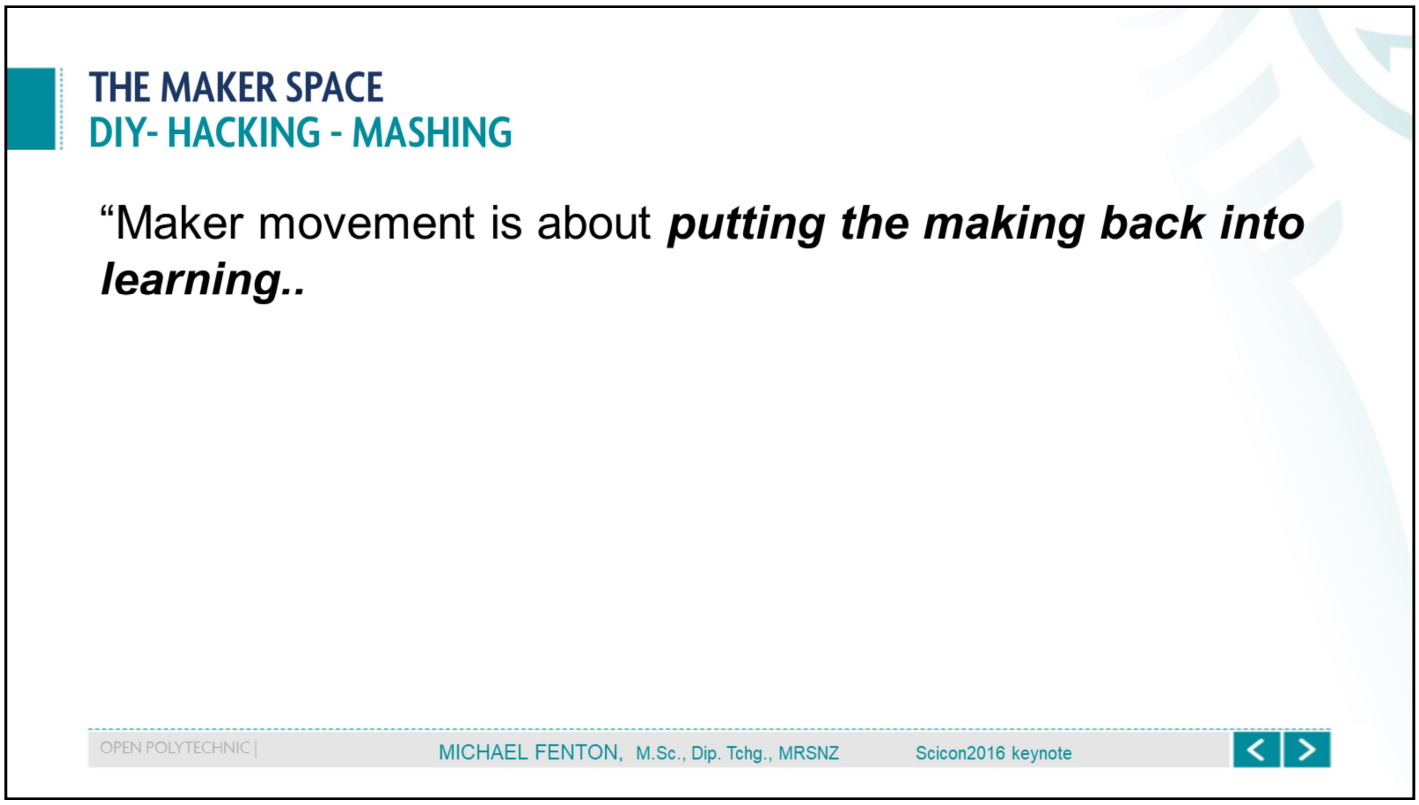


Why is authentic science important? Why is hands-on science important?

Going to the library or going online is not research…it is just passively accepting in an uncritical way second-hand information.

"I did some research in the library…" Far too many low quality science sites online.

Teachers often share resources, perhaps unaware of factual inaccuracies, health and safety issues, etc

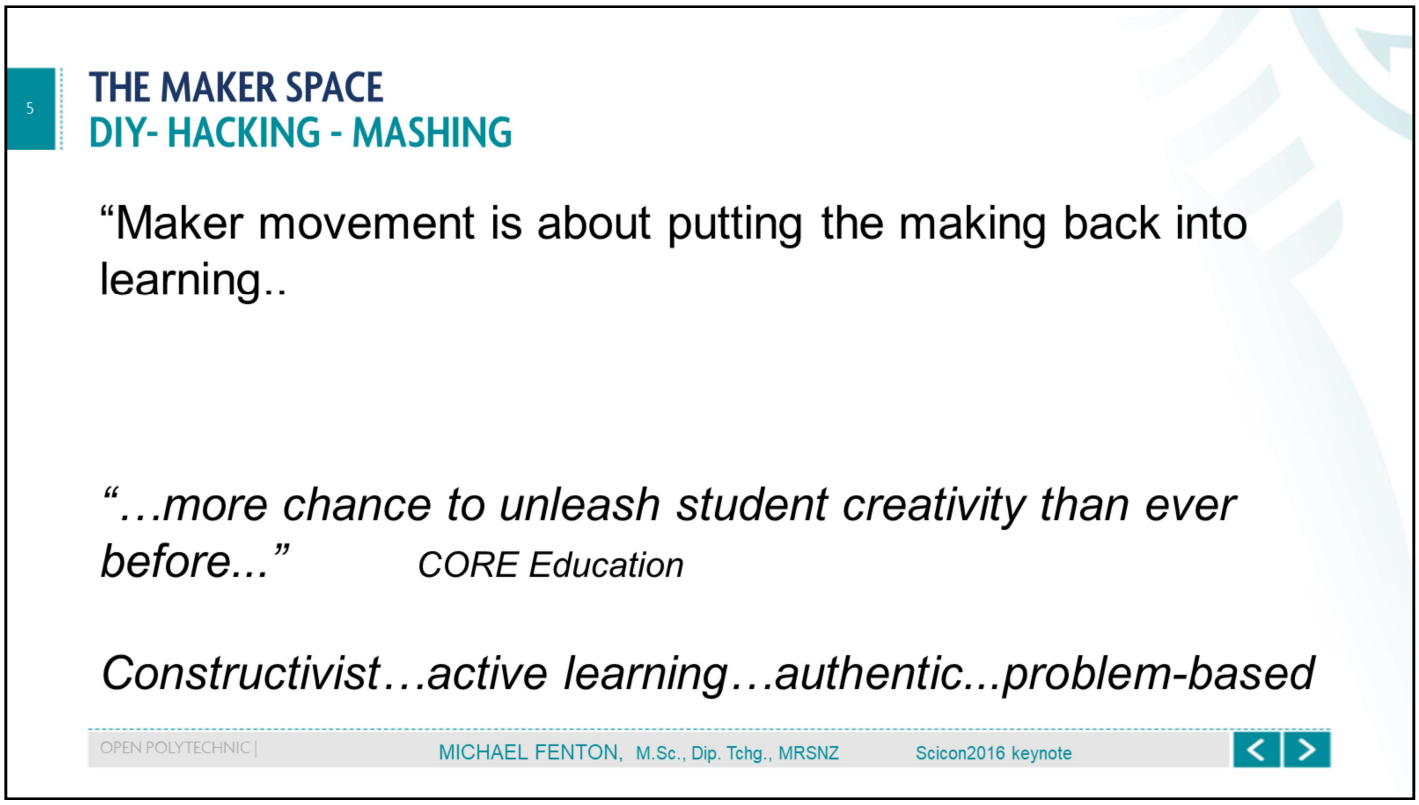
There seems to be a type of amnesia in science education that science has ALWAYS involved observation…seeing for yourself…usually to confirm ideas…so we need to bring this back to the classroom in more meaningful and authentic ways. One strategy I have trialled is to go back to 'old school' science…make the equipment yourself that you need to do the science of interest.

There is already a lot of 'distraction' in education to take teachers and schools attention away from teaching science.

I want to respond to what I perceive as a new ‘distraction’ or threat that is looming on the horizon…the Maker Movement.

I want to challenge some of the astounding claims being made about the ‘benefits’ of this movement, and take away some of the hype being broadcast by some of these ‘wannabe scientists’ or ‘new kids on the block’.

It is disappointing to see some educators uncritically make these extraordinary claims, perhaps revealing their lack of knowledge, expertise or understanding of science or science education.



First note that in the definition I have used here, 'Make to learn" is key here. This will be explore in the slides coming up.

What an extraordinary claim!

" unleash student creativity like never before…"!!

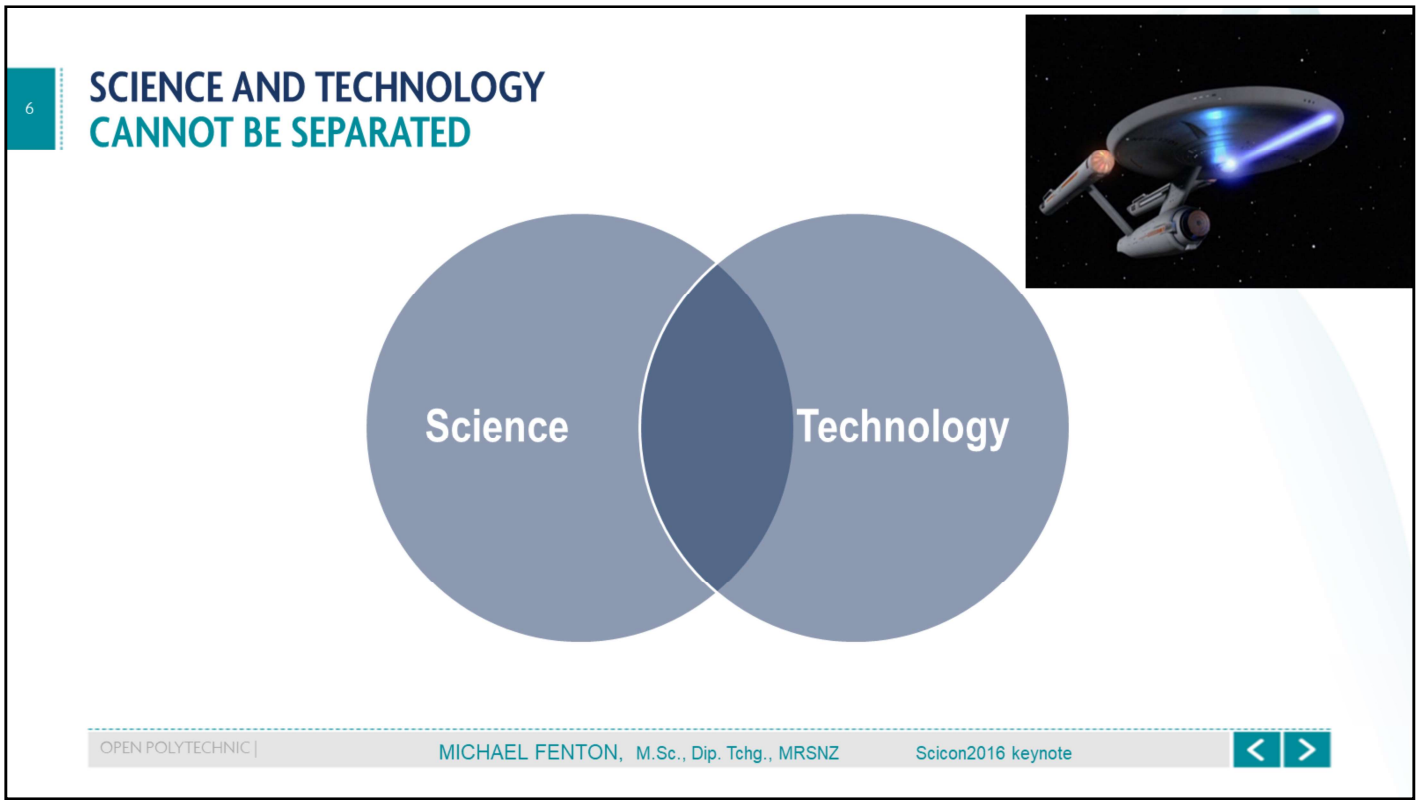
The four aspects given as being unique to the Maker Movement I would argue are already enshrined in science!

Scientific knowledge has always been co-constructed, this is also part of the Nature of Science (as described in the NZC).

We have already heard from presenters and attended workshops covering problem-based learning etc.

There is also a well documented history in science of hacking-mashing-DIY to do science…we cannot separate our use of technology to do science, and using new scientific knowledge to develop new technologies.

Science has been a ‘Maker movement’ with regards to Western Science for over 400 years!



Germ theory example…can you see the microbes on your skin?

Not without a microscope, or growing cultures on nutrient agar (artificial media)

Each time technology gives us a new way to peer at the universe, our perception of it changes.

In Star Trek, Captain James T Kirk and his crew were on a 5 year mission, to seek out new life…but they needed technology, a starship, to do this!

Science requires technology to help us see what our senses miss, we need technology to travel to places we cannot naturally live in (eg, space, undersea exploration, geology such as that done at GNS), etc.

Trying to separate science and technology is unhelpful and artificial….some critics may say in the slides later on I am doing technology…maybe, but to do science! They are still linked!

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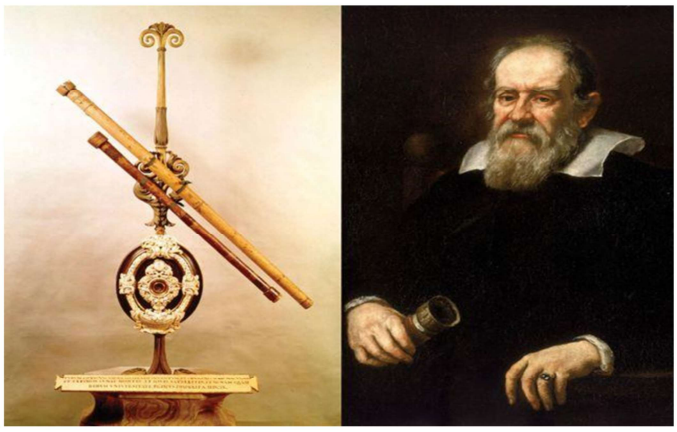
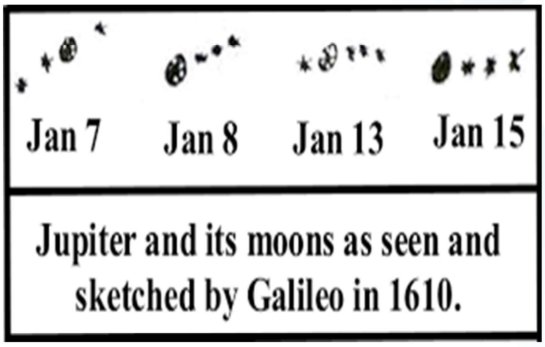
SCIENCE AND TECHNOLOGY – MAKE TO LEARN SHOULD NOT BE SEPARATED





Galileo: DIY telescope made distant object appear closer/larger.

Saw first-hand. Has a huge impact on shifting our thinking to new levels.

Did not read uncritically in a book or online

Revolutionised his cultures dogmatic view that Earth and humans were special, above all else in creation.

All objects orbited an Earth-centred universe.

But with some DIY, seeing first hand for himself…not all objects orbit the Earth.

Ultimately we know WE ARE NOT THE CENTRE OF EVERYTHING!

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YOUNG EINSTEIN
AMATEUR DOES NOT MEAN AMATEURISH

OPEN POLYTECHNIC | MICHAEL FENTON, M.Sc., Dip. Tchg., MRSNZ Scicon2016 keynote

Einstein was not paid to do research when he wrote this famous manuscripts … he was an unpaid amateur or citizen scientist, like Charles Darwin and Isaac Newton before him.

Einstein wondered if gravity was not a force like the electric and magnetic forces, but instead what we experience as gravity was bending and distortion of spacetime. If so, gravity waves should be seen, However, even 10 years ago, the waves predicted were 1,000 the width of a proton, like trying to detect the 'flutter of an angels wings'.

MESSAGE: Amateur scientists can contribute valuable insights (there are many other examples…)

Amateur means unpaid , as opposed to a professional scientist who is paid.

Amateur does not mean 'of no value" or "amateurish"

So students are also amateur or citizen scientists with regards to their Science Fair projects..indeed children and student projects have added to the body of scientific knowledge.

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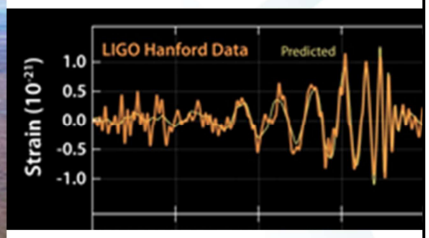
SCIENCE AND TECHNOLOGY – MAKE TO LEARN
CHANGING OUR PERCEPTIONS – CONFIRMING IDEAS



The smallest wave!

1,000 width of proton!

Revolutionised our ability to 'see' the universe…more than light and radio…!!

Notice it confirmed Einstein's thought experiments…needed to see this first hand "flutter of an angels wings".

MESSAGE: Science and technology compliment and reinforce each other

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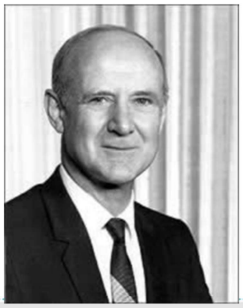
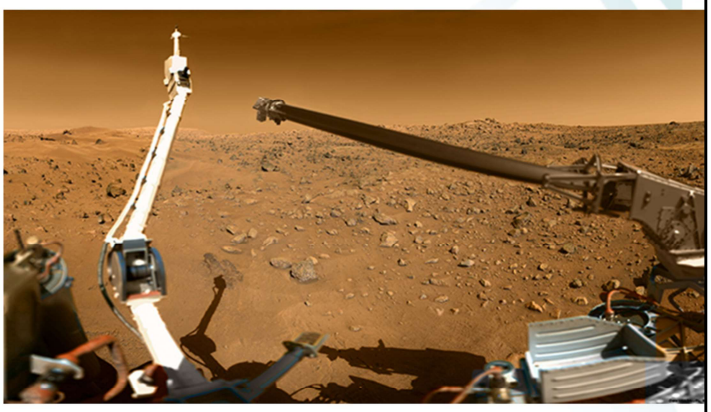
KIWI BILL PICKERING – HEAD OF JPL
MAKE TO LEARN

"More than any other individual, Bill Pickering was responsible for America's success in exploring the planets."





Bill Pickering as the real-life kiwi builder of the original 'USS Enterprise', leading the deep space missions to other worlds, with the mission to detect life. He too needed to use technology to get to other worlds to do the science of looking for life.

The Viking lander may indeed have detected life on Mars after all, but this is still yet to be confirmed.

But the kiwi connection is more than this…time to bring this back to the classroom and how we as science educators can reclaim the Maker Space for Science!

Bring back "Make to learn" in the spirit of Galileo, Pickering and LIGO!

When I first entered teaching after leaving the University sector I decided to keep hold of my own authentic experiences in science…so the first school-based research laboratory was founded in 1997. My wife Dr Christine Fenton and I encouraged students to "Question everything" .

This was NOT a science club….we carried out authentic, problem-based, rich investigations with Year 9-13 students in the role of lab technicians and researchers. This was co-constructed knowledge that was shared between students but new science to be communicated (in the true nature of science) for peer-review.

Our students presented research posters at PROFESSIONAL science conferences, eg the New Zealand Microbiological Society.

This was not a science club…but a chance for students to work in an authentic setting with authentic roles and responsibilities to publish findings, attend conferences, and see what science is really all about!

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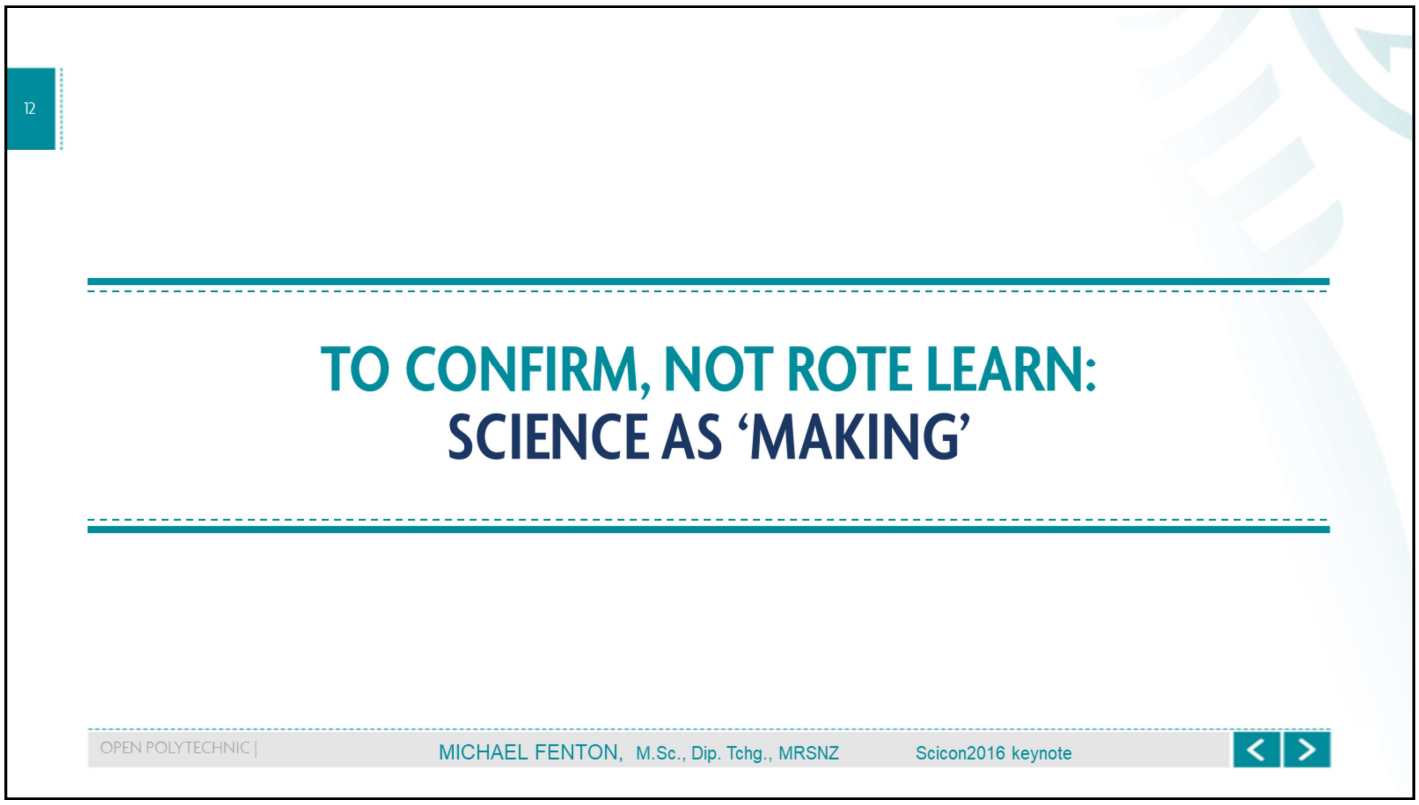
Bill Pickering, the former head of JPL, "The Rocket Man", was our Patron.



Key message is making is transformational with regards to teaching and learning, and more authentically models how scientists work.

Once I was a teacher, then a facilitator…now a science communicator through **Making**.

Making puts ”seeing for yourself first-hand” part of the nature of science

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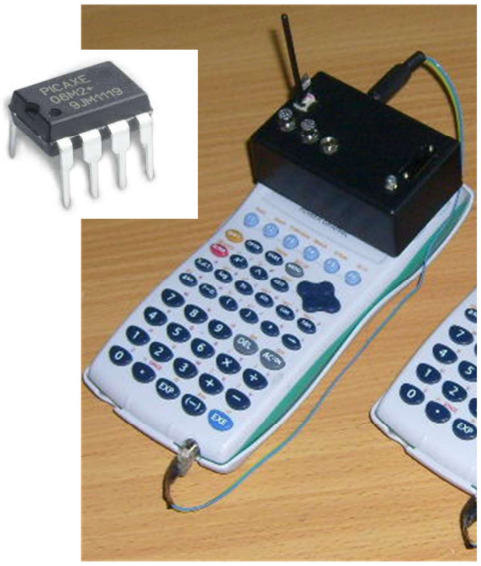
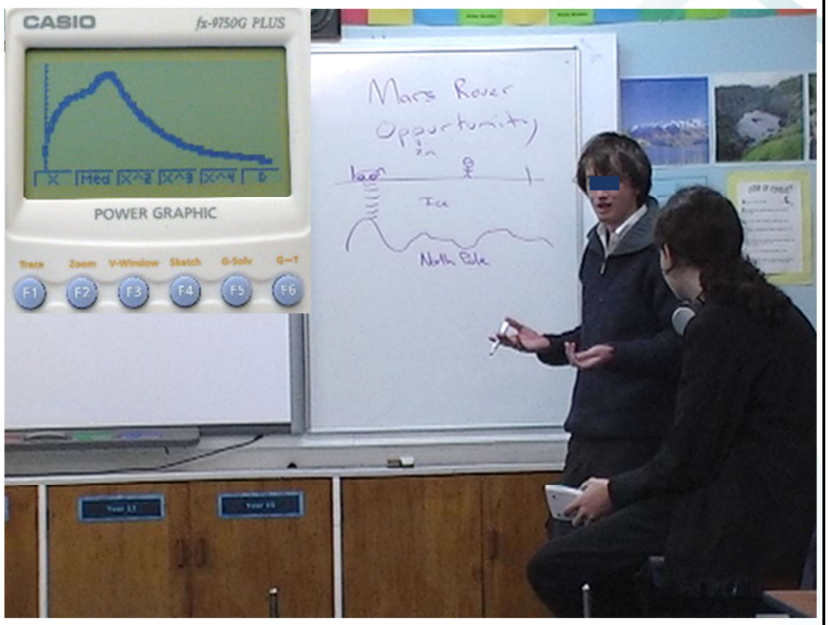
MAKE TO LEARN...
INSTEAD OF LEARN TO MAKE





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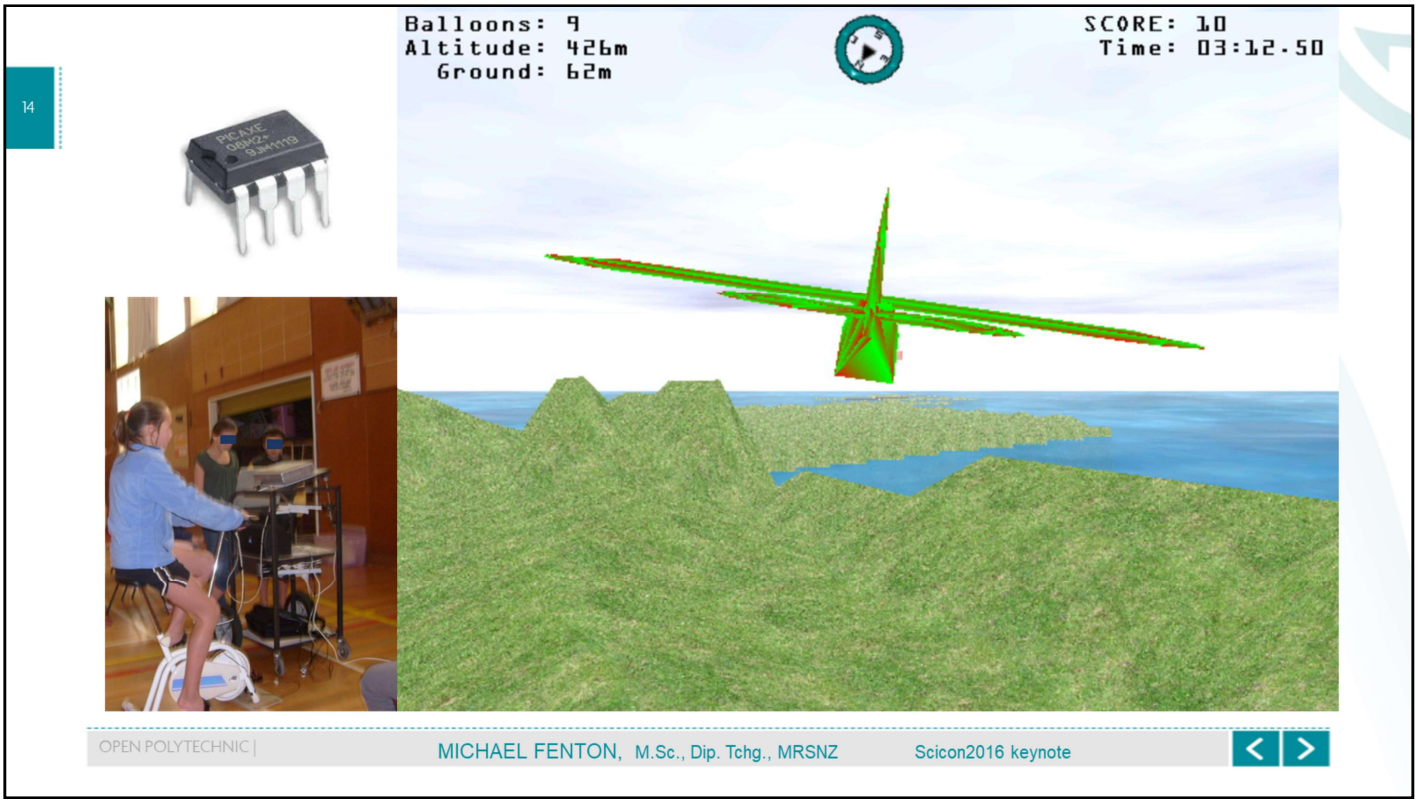
Using $5 PICAXE chips, students helped in design of novel games and electronics link that was a 'universal tricorder', able to connect to Casio graphic calculators, but also connect to other objects to capture human motion and biometric data.

Although he had passed away by this time, I like to think Bill Pickering would have loved seeing my Year13 Calculus class turn their calculators into a Mars Orbiter, fitting an ultrasonic range finder module ($4) to map a simulated Martian surface we built on the classroom flor.

The students captured the data directly into their calculator (see photo) to graph and use applied integration.

Students might forget the Achievement Standard and 'topic' notes, but they said they never forgot the discussions about calibrating the sensors, cleaning the data, and if this was real, the cost and consequences for getting things wrong!

They did learn some calculus too…!



RIGEL attached to excercycle…students used ‘tricorder’ to devise own science investigations and novel sensor systems.

Students love being part of the “Make to Learn” process and even so-called less academic students can demonstrate high levels of thinking using SOLO taxonomy.

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SCIENCE: "TO CONFIRM, NOT LEARN"

OPEN POLYTECHNIC | MICHAEL FENTON, M.Sc., Dip. Tchg., MRSNZ Scicon2016 keynote

Some examples for help teachers become MAKERS and Science communicators;

Very cheap alternative system with multiple sensors…students can take science to their homes. …see more at my workshop on Wednesday

Traditional silos of knowledge such as biology, chemistry and physics as taught in schools no longer match the way science is done now.

The Secondary / High School system is too tied to NCEA; so if you want to revamp science, it is at the Primary level where the greatest impact can be made.

Teachers guide students through 3 steps as they make their own sensor system kits;

- BUILD IT
- TEST IT
- USE IT

Testing may include calibrating sensors to give real-world values, eg, temperature in

degrees Celsius

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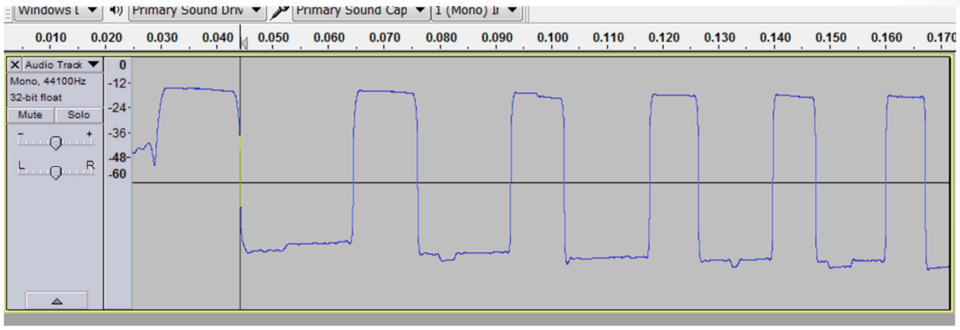
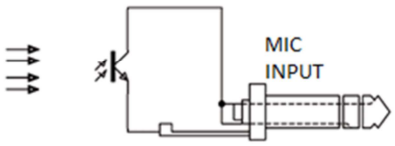
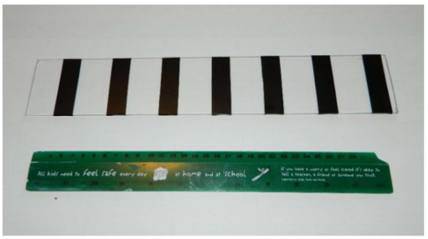
GRAVITY – ACCELERATION CONFIRMED





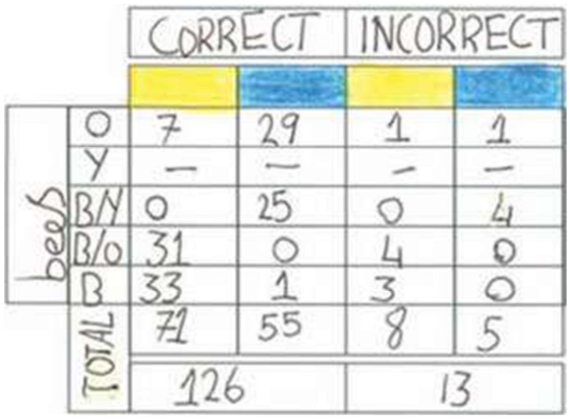


Just like the LIGO…seeing acceleration due to gravity this time, rather than gravity waves.

We must not underestimated the power of seeing things for yourself.

18

STUDENTS AS OLD-SCHOOL AMATEURS!



		CORRECT		INCORRECT	
bees	O	7	29	1	1
	Y	—	—	—	—
	B/Y	0	25	0	4
	B/O	31	0	4	0
	B	33	1	3	0
	TOTAL	71	55	8	5
		126		13	

"We also discovered that science is cool and fun because you get to do stuff that no one has ever done before."

Eight-year-old children publish bee study in Royal Society journal

High school teacher battles bee-killing mites using heated hives

13-year old finds source of fungal pathogen implicated in AIDS deaths

Teachers can become communcators…sharing science discoveries at Science Fairs, or events like Scicon, perhaps even publishing papers!

http://blogs.discovermagazine.com/notrocketscience/2010/12/21/eight-year-old-children-publish-bee-study-in-royal-society-journal/

Aged between 8 and 10, the 25 children have just become the youngest scientists to ever be published in a Royal Society journal.

High school teacher battles bee-killing mites using heated hives

http://newsdaily.com/2015/05/czech-teacher-battles-bee-killing-disease-with-hot-hive/

Science project of 13-year old finds source of fungal pathogen implicated in AIDS deaths

http://www.sciencedaily.com/releases/2014/08/140822084049.htm

DON'T UNDERESTIMATE WHAT STUDENTS (INCLUDING CHILDREN) CAN DO!

Amateur does not mean "of no value" or amateurish!

19

SCIENCE MAKES BETTER CITIZENS

2011 Young NZer of the Year
Jamie Fenton

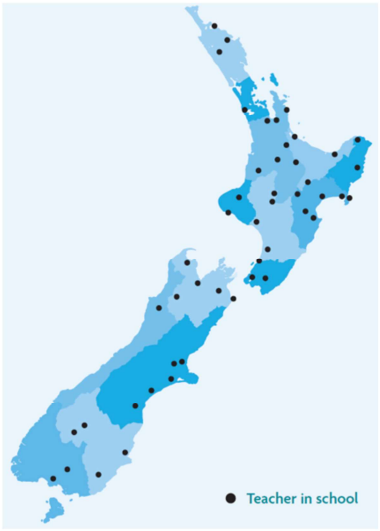
2011 NZer of the Year
Sir Paul Callaghan

Jamie Fenton entered the Taranaki Science Fair with a classroom noise level meter.

Ultimately this was mass produced by the National Foundation for the Deaf, and put into early childhood centres across the country…science benefits the community.

Teachers supporting Science Fairs is crucial to keeping these events going, may be only ‘authentic’ science students get to experience!

KEY MESSAGES
THE MAGIC OF SCIENCE



- Science topics are opportunities to **confirm** by investigation, *not* rote learn
- Students of all ages can participate in real science
- Amateur science has value
- **Make to Learn**

My key messages are realisations I have come to over some 20 years of teaching.. these have been just some stories for you to reflect on, perhaps to be inspired by or challenged by.

So the key messages are actually reminders to myself, but I will share them with you!

THANK YOU

www.openpolytechnic.ac.nz

Michael Fenton

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Scientist / Teacher / Education Lecturer

Science Teaching

Mathematics Teaching

Digital Technology