BREATHE

Breathe is an art, science and technology project to tell the story of the temperature of water along the length of te Wairepo/York stream via a series of internet connected fish replicas.

PROJECT MAITAI

Mahitahi

Nelson City Council

Overview:

Te Wairepo Place | People | Participate is a series of events and artworks aimed at engaging the community with their local waterway. It is a tributary of Project Maitai/Mahitahi funded by Nelson City Council.

The Breathe artwork is part of the Te Wairepo/York Stream Project. It sets the scene for a continuing conversation about the interconnectedness of local environment, and efforts to remediate and care for the waterway and its surrounds.

The project contributes to three outcomes:
- increase of riparian planting and care of the trees along the stream
- decrease in waste (solid/rubbish)
- decrease of toxic waste in the stream (through stormwater)

Breathe is an art, science and technology collaboration which takes the form of a visual representation of the temperature of water along the length of Te Wairepo (York Stream), a local canalised stream, via a series of internet-connected fish replicas displayed in a public venue.

Water temperature directly relates to the amount of dissolved oxygen it carries, and to the ability for fish to breathe.

This project seeks to encourage the groups involved to practise kaitiakitanga (guardianship) of their part of the waterway, taking direct action to reduce the temperature and therefore improve fish habitat.

This document is provided as a resource for recreating a similar work in other waterways. It provides the format and some of the learning. It is distributed under a creative commons share alike and attribution licence and users of the document are encouraged to contribute to the ongoing refinement of the project.

Timeline and Format for the workshops:

Breathe involves a core group of ten students from four schools located along the length of the waterway. The students participate in a series of workshops to help them understand the scientific, cultural, creative and technical perspectives of the project. Learners construct an IoT (internet of things) in the form of the data gathering sensors recording the temperature of the water in Te Wairepo/York Stream. The Nelson Provincial Museum provided the initial outlet for their combined work.

Each school group takes part in two workshops;

- the first to introduce stream ecology and art as a communication tool
- the second to construct and oversee ten data gathering sensors to be able to monitor the temperature for their part of the stream.

Workshop part A: the mauri and toi

The workshop begins with a karakia. This places the work within the kaupapa of a maori world view. It raises the profile of the waterway and describes care for the stream from the perspective of four fresh water species. This happens by looking at ideal conditions and things that will impact or assist the fish. Students also take a brief look at insects in and around the stream and what they tell us about water conditions.

The participants then explore the creative process of developing a vehicle to communicate one aspect of that with the public/community (temperature). They do this by marking patterns and symbols onto a laser cut acrylic fish, seeking to describe cool, clear and flowing.

Key points in the workshops:

Workshop A – Mauri and Toi - River Ecology, Art and communication:

The stream ecologist is instrumental in students understanding the cultural and scientific perspectives of the work.

Materials:
Examples of fish and their life cycles, food sources and ideal conditions for life Images and patterns from nature and the world around us

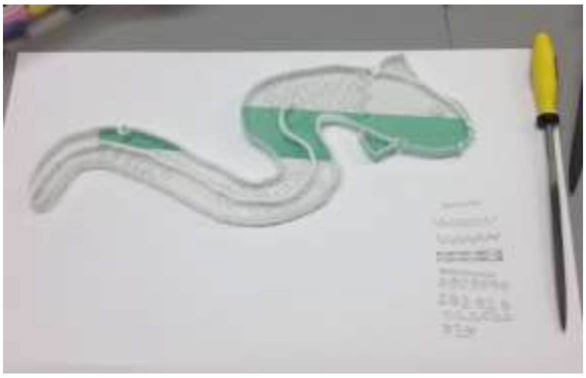
Laser-cut acrylic fish, sets of needle files, paper and pens

Facilitators	Introduce the idea of artworks being able to tell a story Breathe artwork as a whole, what it will look like and the outcome
Key question:	How do you think fish breathe?
Ecologist	Start with a karakia – what it is and why we do it (cover the mauri and its importance) Look at each fish and what they need Inanga – lowland species short lifecycle and spawning now Koaro – galaxiids how they got their name? Bullies – as a fish are tougher! Tuna – their long life cycle Even if cleaning up the stream takes a long time there will be ongoing future benefits
Key Questions	What do they have in common? (All require oxygen to enable them to breathe) What are the ideal conditions to keep these critters happy Cold clear flowing (discuss temperature and oxygen)
Artist:	Mark making and how to individualise the fish through original patterns. Reflecting on the information from the Ecologist participants experiment with describing what are good stream conditions. They could produce other designs; light on water or the patterns of the fish species themselves.
Key question:	What patterns do you notice in nature? What patterns and designs are on things we use (in weaving, banknotes, walls)

Hand out the fish

Students can ask questions and talk about their ideas about the stream (what they observed)
A simple process for each design might be to create an element on paper and replicate; or draw around and design the entire pattern on paper first then place the fish on top to scribe and make marks

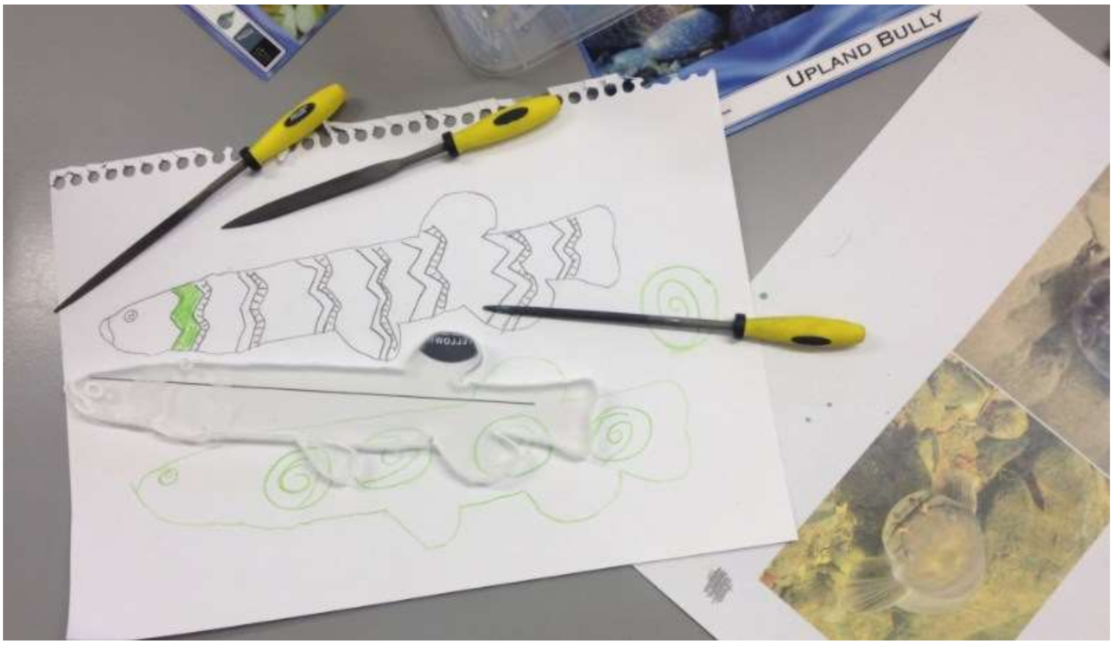
The students from Auckland Point are the '*Enviroschool'* group here working on the mark making patterns as story using ideas of the ideal conditions. They are physically embedding, through mark making, their learning about fish species and river conditions.



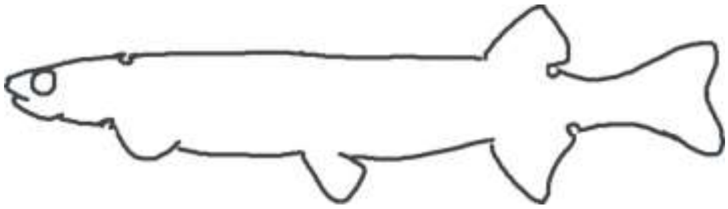
A student creates a legend of patterns for her fish

One important point from this process is that although the introductions included discussion of Te Wairepo/York stream and its path through their community, we still started this work in a classroom. Students from a couple of schools had already been involved in work around the waterway, at Victory for example the student cohort included three who had taken part in previous artworks about their expectations for Te Wairepo. The stream ecologist also recognised students who had been involved in trips with her to the Brook Sanctuary.

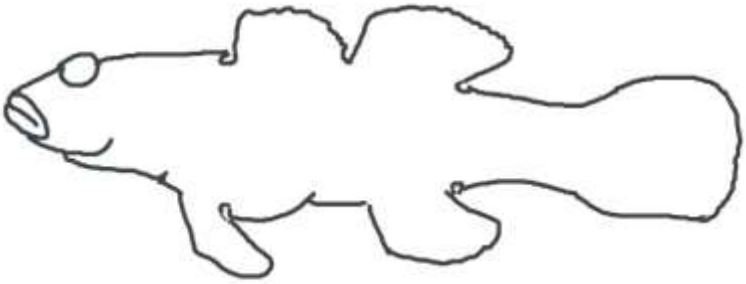
In ideal conditions the students would have begun this project on the banks of Te Wairepo



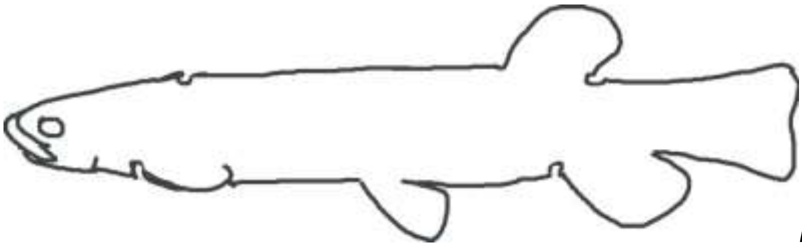
The path of light reflections through clear water adorn this koaro



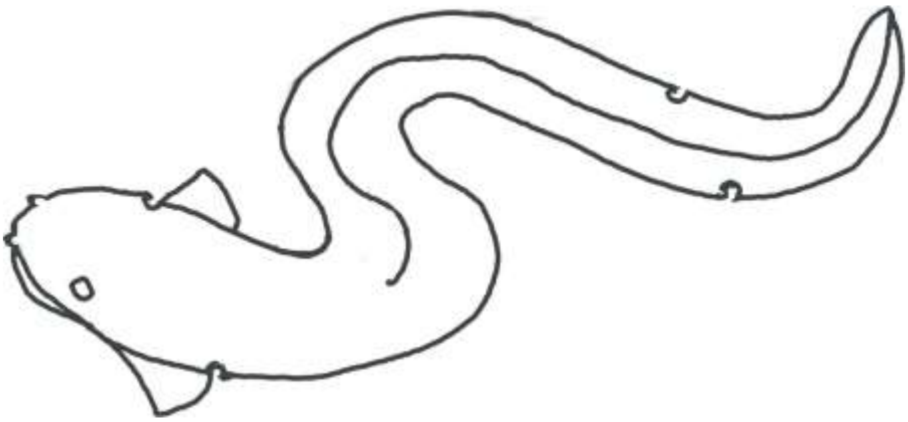
Inanga



Bully



Koaro



Tuna

The fish species were chosen to include a range of life cycles and habitats, but also for the differentiation of shapes they provided. Although in this illustration the Tuna (eel) is larger, in the artwork they are all the same size. The notches in the design were added to facilitate hanging them using strung wire without interrupting the LEDs. A vector graphic file of the outline is required to create the acrylic fish using a laser-cutting machine. The current work uses ten millimetre clear acrylic, they are etched and laser-cut.

Involving the students in the choice of fish species and their design would be another way to embed understanding of stream inhabitants and the conditions they require.

Workshop part B: The technology, data gathering machines are created and tested within a local environment, ideas for future outputs will be discussed

<table>
<tr><td colspan="2">Workshop B – Technology and Sensor - data and communication:

Materials: Picaxe breadboard, temperature sensor, LED
Radio 433mHZ radio link to transmit to receive (serial ASK data link)
Different temperature reading opportunities (a glass of ice, a fan heater etc)</td></tr>
<tr><td>Facilitators</td><td>Introduce the outcome for the day (of creating a data sensor)</td></tr>
<tr><td>Key question:</td><td>What is an important thing to record in terms of available oxygen in streams?</td></tr>
<tr><td>Creative Technologist</td><td>Overview of the Picaxe technology
Set everyone up with components to create a series of sensors</td></tr>
<tr><td></td><td>Using a breadboard solder-free process the students create a circuit and construct devices that can relay information about the immediate environment, Including constructing of the temperature sensor.

While doing so they gain an understanding of how the technology works and how the data will be transmitted and received.

Once set up, the students are able to see changes in the temperature readings by putting the temperature sensor in a range of environments (eg. in their hand, out the window and in a glass of ice)</td></tr>
<tr><td>Key question:</td><td>What patterns might we notice after the data has been collected over 24 hours or over a week or a year?</td></tr>
<tr><td colspan="2">Students can ask questions and talk about their ideas (what they observed) and what they might already be interested in thinking about in terms of their data.

The initial workshop showed the temperature as a series of flashing lights (via LED). The students counted flashes to figure out the temperature (eg long for tens, quick for ones, very quick for decimals).</td></tr>
</table>

At the end of Workshop B we collect the completed fish and sensors (checking all are named for ensuring the correct correlation of the data). An online spreadsheet ensures the sensor corresponds to the correct fish and the data collected can be tagged to each student (for future projects).

Students look for the greatest range in temperatures

"There are great opportunities for getting people connected to real and meaningful stuff in a fun way." Andrew Hornblow, Creative Technologist

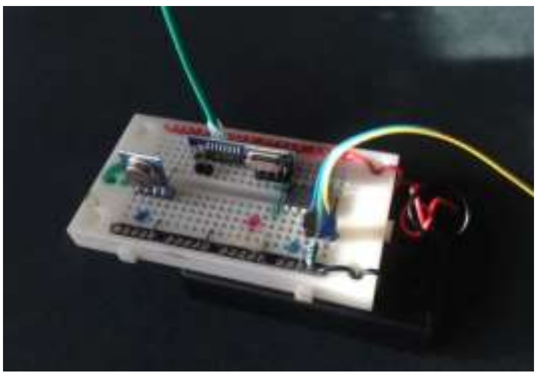
'Victory Primary students with their school of sensors and fish ready to deploy!'

Technical specifications:

Without transcribing every line, written below is essentially what is happening at the code level. The protocol used is a *do* loop that measures, transmits and pauses.

```
++++++++++++++++++++++++++++++++++++++++++++

do

readtemp12 4,w1
'Read the 12 bit resolution temperature word w1 from the probe

w1 = w1 * 10 / 16
'scale the raw value to byte value 0->255 = 0.0->25.5 Deg C
b10 = "D"
'Unique student data packet instrument channel code ID A > J  b12
= b10 XOR w1
'Calculate data packet check sum using XOR function

serout 0,N2400,(85,85,85,":01",b10,w1,b12)
'Transmit Preambles=85 + Node_ID=01 + Student_ID=b10 + Data=w1 + Check_Sum=b12

Time_Delay:
nap 7
'Ultra low power 5 second sleep allows for year + battery operation

loop

++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

2/. An ASK 433mHz radio transmitter from each of 10 instruments transmits an ad hoc data packet every 5 seconds to one Raspberry Pi + ASK receiver per school. The Data at the Pi is checked for errors and as it arrives is then passed on to the artwork. Data from the Pi is transferred over the www using MQTT protocol.



Above is the coding screen for the Picaxe (this is a very simple and extendible system and has the potential for a range of data collecting applications). On the right is a unit showing components to both the send and receive.

BREATHE: Funded through Project Maitai (Mahitahi): Nelson City Council / Te Kaunihera o Whakatû

Readying the tech for the deployment.

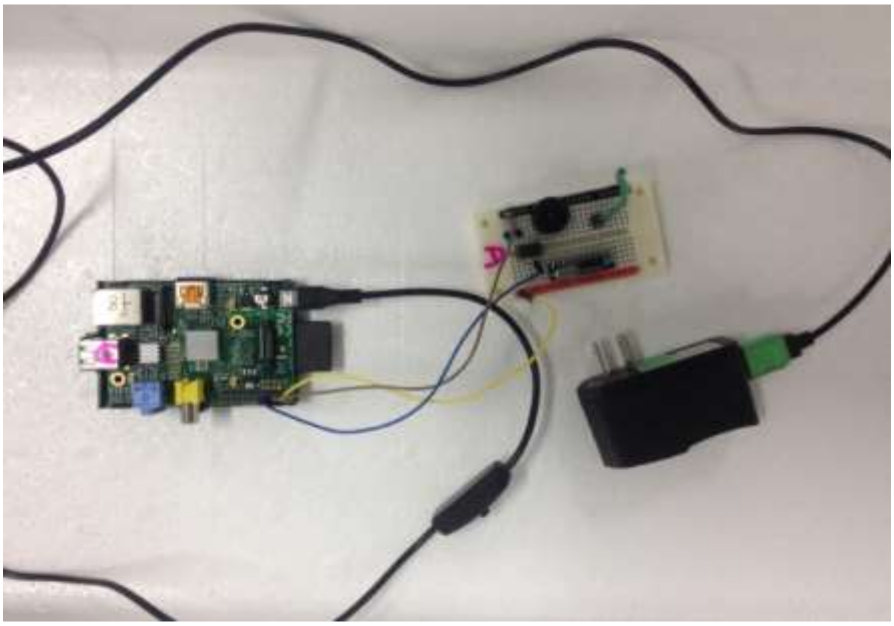
A working bee will be held to construct the sensor housings. Students are welcome to come with their parent or caregiver to see /take part in this aspect but it is not a requirement. A group from the Light Nelson Artist collective built the sensors housings. In future iterations, the group creating the work would ideally be supported to undertake this themselves. Students and family members or members of the community building the housings would be an ideal form of engaging a wider participation and audience for the work.

The unit has a wire soldered to a bolt, which is mechanically attached to a length of tensile wire to extend the aerial. The temperature sensors were also extended with extra Cat 5 cable to ensure enough length (we made these 3 metres – in some cases they could have been longer).

The small sealed containers were housed inside Marley pipe (sourced from the recycle centre) and with an additional treated ply and painted roof. The unit was bolted through the pipe with the aerial externally attached. In deployment the whole thing was cable tied to either a piece of reinforcing steel or existing structure along the stream.

Due to health and safety considerations, the students were not responsible for deploying the sensors in the stream. Ideally, actively involving the students in the placement of the sensors (to determine how best to understand the difference in stream conditions) would be the most useful scenario.

Gathering the Data



Each site (in this case school) involved needs to be able to host a gathering device that requires power and access to the internet (wifi or cable). Above is the first prototype with a Picaxe receiving the radio signal and transferring it to a raspberry Pi to upload.

Due to the vagaries of radio signal it was determined that the original Picaxe Pi configuration was causing signal noise. A second Pi was tried which improved things markedly. There are now two sites transferring the data via a wemo device. The only consideration with this is the need to programme in the wifi and the potential for more ‘signal noise’ (the two sites currently appear to be working well).

The output array – from the water to the fish

The output array draws the data from each sensor and assigns it to the individual fish via a publish and subscribe protocol MQ Telemetry Transport (MQTT) a machine to machine transfer becoming increasingly popular with IoT (Internet of Things) applications.

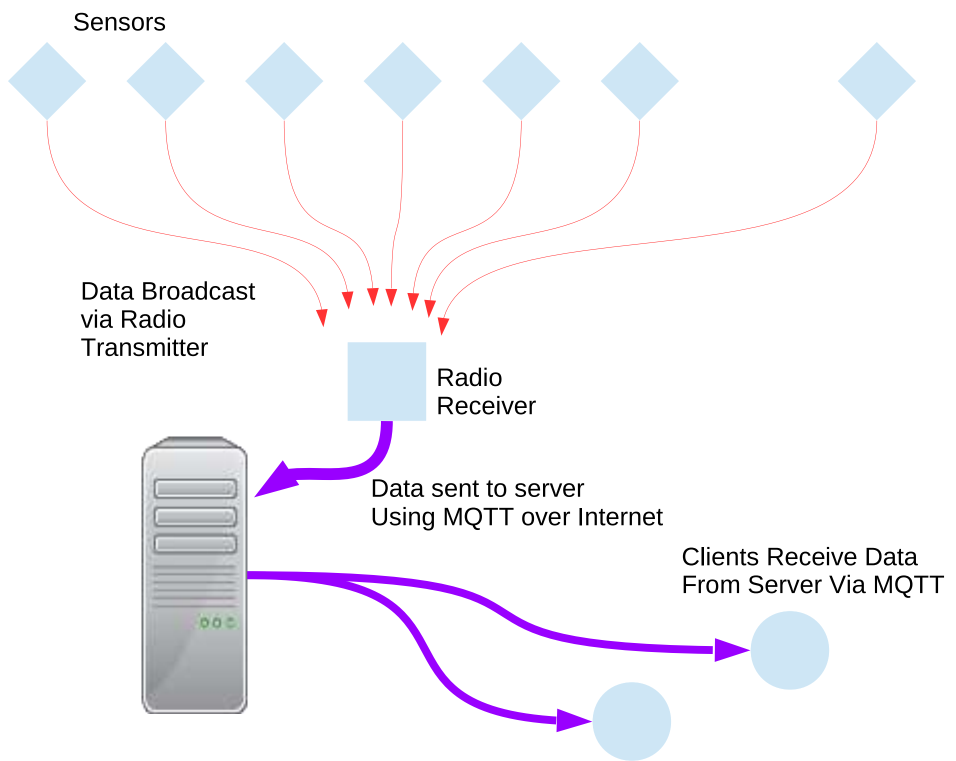
++

The Wemo/Raspberry Pi reads Serial a line of text via serial from the Picaxe of the format 'A,B,123' where 'A' is the School, 'B' is the Fish and '123' is the temperature.

It splits up the line into those components and then sends the fish code and temperature to the MQTT broker on a topic named 'breath/X' where the 'X' is the school letter.

The Clients connect to the broker and subscribe to each of the breath topics ('breath/A', 'breath/B' etc.) and wait for data which comes in in a similar form as above but without the school code ('A,123').

++



The path of the data – from the server many devices can also access the MQTT stream

BREATHE: Funded through Project Maitai (Mahitahi): Nelson City Council / Te Kaunihera o Whakatû   CC-BY3.0 NZ

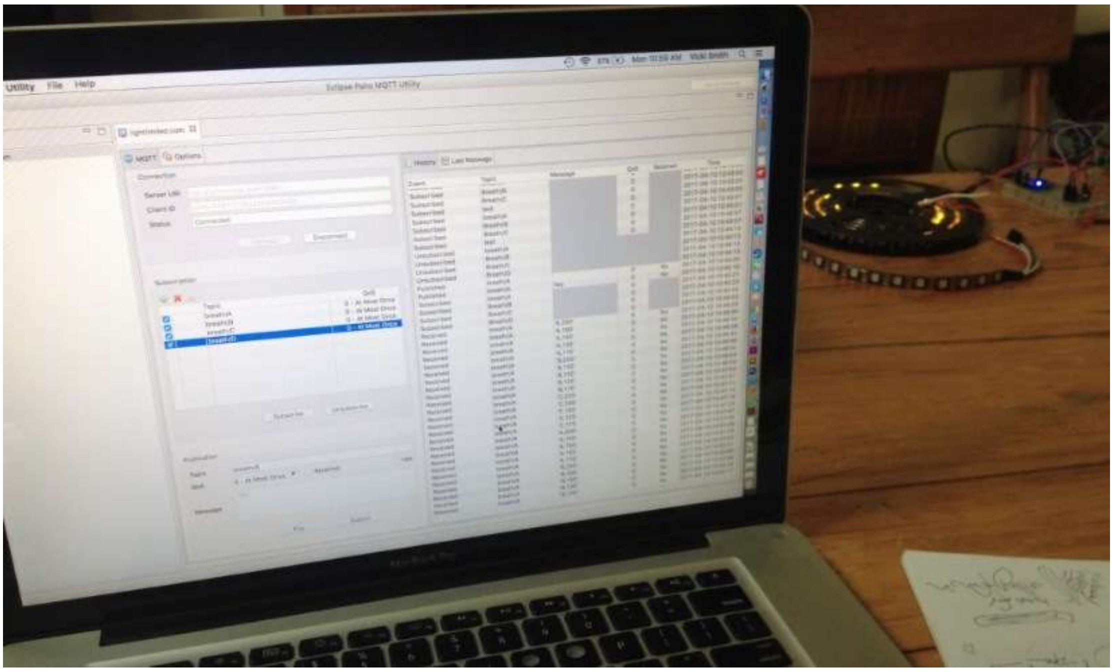
The test install above shows the wemo driving the LED string. The final work relays the temperature data for each school. In order to have all fish operating the programme currently ‘fills’ any missing sensor with data from those adjacent. It ignores the data from the air temperature sensor from that process.

Accessing the temperature data story

There are a myriad of clients for MQTT so here are just two;

http://mqtt.org/

The Eclipse Paho project is the reference implementation for the MQTT protocol it has a large open-source community making it very well supported.



A Paho Client reading the data, on the right the LED string relays temperature as colour
MQTT Dash can be found in Android Apps (Google Play)

Details required to access are:
Your name or client ID (in dash you can just make this up – but be original) The address – where the server is
The port: 1883 is an open channel 8883 (for SSL – Secure services)

Then, as in the case of the four schools that are part of the Breathe project, you need to subscribe to the channels (eg School A etc).

For Breathe the details are:
Name: (anything – must be original as in no replications).
URL: lightlimited.com **port:** 1883
(NB: in Paho this is all together as tcp://lightlimited.com:1883)

Each stream must be connected to individually
The streams are; Breath/A (Auckland Point) Breath/B (Victory Primary School) Breath/C (Nelson Intermediate School) Breath/D (Nelson College for Girls, Bronte House)

There is a good read about various clients at: http://www.hivemq.com/mqtt-toolbox

There is a quick version of the eventual data gatherer that you can access on line - it's accumulating the data from all the receivers into the following file:

https://lightlimited.com/breathe/livedata.txt

Format is straight forward, just a single line of comma separated values latest figures from the last 5 minutes - Timestamp followed by school character and ten values for each school.

Acknowledgements:

Breathe is a collaborative artwork and has been possible thanks to the efforts and generosity of a large number of individuals and organisations:

The students and staff of; Auckland Point School, Victory Primary School, Nelson Intermediate and Nelson College for Girls (Bronte House).

Key contributors; Mel McCoglan Stream Ecologist, Andew Hornblow Creative Technologist and John-Paul Pochin Software Developer

Cawthron Institute: Dr Roger Young Group Manager Freshwater Sciences

Light Nelson Artist Collective members; Frog & Hazel Twizzell and Jonathon Neil

Maker&Co – Shane Eriwhata: Fluid Power Solutions, Redpaths for donating materials and the Goodwins [hosting a data gathering device]

The Nelson Provincial Museum staff especially
Lucinda Blackley-Jimson – CE | Jim McKay – Technician| Matt Frost: Graphics

This project was instigated by artist Vicki Smith as one of a series of art works and events for the Te Wairepo/York Stream Project.

Te Wairepo/York Stream is a tributary of Project Maitai (Mahitahi), funded by Nelson City Council Nelson City Council/Te Kaunihera o Whakatû

Enquiries about the resource should be made to:
Email: Joanna.wilson@ncc.govt.nz