



NCEA Level 2

DIGITAL TECHNOLOGIES & HANGARAU MATIHIKO

Teaching and learning programme

Electronics – Monitoring water quality



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Summary of the teaching and learning programme

Monitoring real-world ‘things’ is an easily accessible and authentic context for learners. When done well, it can quickly provide meaningful data from which to make informed decisions. For this teaching and learning programme, the big question posed to students is: What can we monitor over time to better understand local water quality? It is possible to pose this open question to students and let them determine the direction of the outcome or, as a teacher, you can select a specific monitoring project for the class.

This programme provides guidance for teachers to engage students in the development of electronic sensors to monitor temperature, web database systems (PHP and MySQL) to store temperature data and web pages (PHP or HTML) to view data in real time.

By the end of this teaching and learning programme, students will be able to:

Use design tools to generate ideas for a real-time monitoring system. This will include using digital tools and relevant design conventions to generate ideas for all aspects of a digital technology outcome, including system block diagrams, circuits schematics, enclosure mockups, database tables or fields, and web-page wireframes. Students will then develop and test electronic sensors that can send data packets to a MySQL database, develop web pages that can access a database and retrieve and display data in a range of formats including text, tables, and charts.

Duration

It is important to allocate at least 2 terms (approximately 50 hours) for this programme of learning. This will allow time for students to design, develop and present a summary of their learning.

The big ideas

Students are guided through a design and development process. Within the process, students are exposed to the concepts of:

- electronic sensor development
- selecting and displaying data from a MySQL database (read-only)
- using HTML to display data on a web page
- modelling (trailing and testing) and using feedback to improve on a design and final outcome.

Alignment to the New Zealand Curriculum

DDDO – Designing and Developing Digital Outcomes: Progress outcome 5

In authentic contexts and with support, students investigate a specialised digital technologies area (for example, digital media, digital information, electronic environments, user experience design, digital systems) and propose possible solutions to issues they identify. They independently apply an iterative process to design, develop, store and test digital outcomes that enable their solutions, identifying, evaluating, prioritising and responding to relevant social, ethical and end-user considerations. They use information from testing and, with increasing confidence, optimise tools, techniques, procedures and protocols to improve the quality of the outcomes. They apply evaluative processes to ensure the outcomes are fit-for-purpose and meet end-user requirements.

Links to other learning areas

This programme is about data collection and graphical display and could be integrated with science and/or environmental education courses.

Teaching and learning pedagogy

The methods and practices of teaching and learning that will enable success in a programme like this are summarised as ‘teacher-guided, project-based learning’. The teaching and learning programme has been developed in a way that teachers can guide students through the design and development processes.

Prior knowledge and place in the learning journey

It is advisable that students have a broad range of knowledge and skills prior to this work, including electronics system development. This would include basic programming of a microprocessor, programming (any language) and web media (HTML) at year 10–11. If students have not been exposed to this knowledge, key learning outcomes in term 1 of the year (prior to starting) would need to include:

- using an Arduino or Picaxe microprocessor to measure the air temperature of the classroom
- developing a simple HTML web page that displays images, text, and hyperlinks about a topic of interest
- developing a computer program that creates a list or array and iterates through the array to output text.

Resources required

These resources are supplied:

- [Teacher Workbook to support AS91891 & AS91897](#)
- [Student workbooks](#)

This is a practical learning programme and requires some specific resources.

Resources for electronic sensor development:

- prototyping equipment: Breadboard, 4.5v or 6v battery pack, jumper leads, LED (5mm)
- microprocessor such as Arduino or Picaxe with download cable
- temperature sensor such as a DS18B20 Dallas temperature sensor
- resistors ranging from 330 ,470, 1K, 4K7, and 10K
- radio transmitter or receivers, such as Dorji ASK modules or the long-range Dorji DRF1268DM.

Resource for internet gateway:

It is best that the teachers or school set up the internet gateway and web server. This is the device that will receive data from the student's radio transmitters, and using an HTTP POST request, will send the data to a server-side script, such as a PHP file.

Examples of the internet gateway and PHP file are provided.

- A good internet gateway device is an ESP8266 board such as a NodeMCU or Wemos. Connect up the board to a radio receiver module.

Resource for web server and web pages:

- HTML and PHP code editors such as NotePad++ or Brackets.io or Atom
- Using a LAMP server is often the best.
 - Ask the school IT technician to set up a subdomain such as monitor.myschool.school.nz.
 - Configure the VHOSTs files to send traffic to a folder you have access to.
 - In this folder, place a storeData.php file that accepts the data and inserts this into a MySQL database.
 - In this folder, place a showData.php file that outputs in raw text at least 100 data points. This is helpful for students as they set up their sensors.

How might you adapt this in your classroom?

Adapting this programme could include:

- monitoring soil moisture over time to gain data on plant health. Local gardens provide opportunities to monitor soil temperature or soil moisture. Teachers could place pot plants in the classroom and build sensors to monitor the health of these plants.
- monitoring indoor temperatures over time to gain data on the effective use of heating systems
- monitoring water temperature and water conductivity to gain data on water quality characteristics
- monitoring air temperature and air moisture outside the classroom.

Assessment

There are two key assessments:

- AS91891 Apply conventions to develop a design for a digital technologies outcome
- AS91897 Use advanced processes to develop a digital technologies outcome

TERM OUTLINE

An important note: Students' learning is not linear. Often learners need to design and develop at once in order to test their understanding and test the feasibility of an idea. This is a good thing within the learning process and should be encouraged. It is the job of the teacher to make sure that learners meet all aspects of the achievement standards

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
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Section 1 Develop a design 18-20 hrs

The main focus of this section is on the design and modelling of a monitoring system capable of grabbing real-time temperature data and transmitting this to the internet.

Students create a Google Document for collecting evidence for assessment of AS2.2.	10 min	Teachers set up a document owned by the teacher, similar to how Google Classroom manages student work. This will allow both teacher and student to manage the collection of evidence for the unit of work.	Google docs
Students research and decompose a monitoring system into each part.	1 hr	<p>Teachers and students break down the process of monitoring physical variables, such as temperature.</p> <p>The teacher decomposes the monitoring system into a series of steps or stages, processing temperature inputs and sending data via radio link, receiving data and posting to web server, storing data on a web server, and finally displaying data via HTML. It is worth sketching the basic ideas and adding more detail to these sketches as time goes on. (This is the beginnings of a system block diagram.)</p> <p>Students create a heading Project Overview and place in their simple sketch or block diagram of all aspects of the monitoring system.</p>	Internet

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
Students are given the question: What can we monitor over time to improve its performance?	1 hr	<p>Students create a heading Project Ideas and collate all ideas.</p> <p>They list at least 4 physical quantities that could be monitored:</p> <ul style="list-style-type: none"> • reasons for monitoring (purpose) • location of monitoring • information that could be gained • ease of access, and issues or health and safety concerns. <p>Ideas could include lake temperature, lake level stormwater volume, stormwater temperature, stormwater quality, stream level, stream temperature, garden soil temperature, indoor pot-plant-soil temperature, classroom air temperature.</p>	
Students describe the purpose and end-users of the outcome.	2 hr	<p>Teacher Workbook AS91891 (AS2.2)</p> <p>Students create a heading Purpose and End-users and add information.</p> <p>They read Stage 1</p> <p>They answer questions.</p>	<u>Teacher and Student Workbook AS2.2</u>
Students investigate design tools and design conventions.	1 hr	<p>Teacher Workbook (AS2.2)</p> <p>Students create a heading Design Tools and Conventions and add information.</p> <p>They read Stage 2: Students research the different design methods and design conventions used.</p> <p>Teacher Workbook AS2.2</p> <p>Exercise in Stage 2: Students research their chosen design tools and design conventions</p> <p>Exercise in Stage 2: Students describe the design methods and conventions.</p>	<u>Teacher and Student Workbook AS2.2</u>

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
Students research and explain implications relevant to their outcome.	1 hr	<p>Teacher Workbook AS2.2</p> <p>Students create a heading Relevant Implications and add information – they need to say how they would address the top three implications.</p> <p>They read Stage 3</p> <p>Exercise Stage 3: Students read through each of the relevant implications and ranks them from most to least important and why they think this.</p> <p>Teacher Workbook AS2.2</p> <p>Exercise Stage 3: Students discuss implications with teacher, potential users and other students and selects 3 or 4, explaining how they impact on the development and outcome of the project.</p>	<u>Teacher and Student Workbook AS2.2</u>
Students use design tools to generate a range of design ideas.	6 hr	<p>Teacher Workbook AS2.2</p> <p>Students create a heading Generating Ideas and add information.</p> <p>Stage 4: Students read the example ideas in the workbook.</p> <p>Students then generate designs that include:</p> <ul style="list-style-type: none"> • system block diagram • circuit schematic for electronic sensor • design ideas for data to collect, send and store in a database • design ideas for a web page to display data. 	<u>Teacher and Student Workbook AS2.2</u>

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
Students model design ideas.	4 hr	<p>Students create a heading called Modelling Ideas and add feedback from the teacher, exports, research and end-users.</p> <p>Stage 4: Students read the section on modelling design ideas.</p> <p>They model their ideas and use feedback to improve the outcome.</p>	<u>Teacher and Student Workbook AS2.2</u>
Students select and justify design ideas.	2 hr	<p>Teacher Workbook AS2.2</p> <p>Students create a heading Select and Justify and add information.</p> <p>Exercise Stage 5: They list the design tools and conventions used, also the relevant implications they chose for the outcome.</p> <p>Teacher Workbook AS2.2</p> <p>Exercises Stage 5: Justify their chosen design ideas.</p>	<u>Teacher and Student Workbook AS2.2</u>

Section 2 AS2.8 Use advanced processes 20–25hr

The main focus of this section is on the development and testing of a digital technologies outcome. While the outcome is made up of electronic and web components, it is possible that one or both aspects may be assessed.

1. Development of an electronic monitoring system capable of grabbing real-time temperature data and transmitting this to the internet
2. Development of a web page using HTML and PHP that reads data from a database and displays the data via tables or charts.

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
Students sign up and create a www.trello.com board	20 min	<p>Teacher Workbook AS2.8</p> <p>Students create a heading Project Management and add information.</p> <p>They read Stage 1: Students set up a Trello board to help manage the tasks they need to complete.</p>	<u>Teacher and Student Workbook AS2.8</u>
With teacher guidance, students decompose the outcome into components	2 hr	<p>Teacher Workbook AS2.8</p> <p>They read Stage 2: Decomposition</p> <p>Students create a heading Decomposition and add information.</p> <p>Students need to decompose the outcome into key components (This is best done with teacher guidance.):</p> <ul style="list-style-type: none"> • electronic sensor • internet gateway • server scripts for inserting data into and creation of MySQL database • web page for display of monitoring data. 	<u>Teacher and Student Workbook AS2.8</u>
Students research and explain implications relevant to the outcome.	1 hr	<p>Teacher Workbook AS2.8</p> <p>Students create a heading Relevant Implications and add information.</p> <p>They read Stage 3</p> <p>Exercise Stage 3: Students read through each of the relevant implications and rank them from most to least important.</p> <p>Teacher Workbook AS2.8</p> <p>Exercises Stage 3: Students discuss implications with teacher, potential users and other students and selects 3 or 4, explaining how they impact on the development and outcome of the project.</p>	<u>Teacher and Student Workbook AS2.8</u>

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
Students' development, trialling and testing of the outcome.	16 hr	<p>Teacher Workbook AS2.8</p> <p>Students create a heading called Development, Trialling and Testing and add information.</p> <p>They read Stage 4: Development, Trialling and Testing</p> <p>There are a number of stages outlined in the workbook for guidance. Where to Start Development has clear steps for learning the content for the course:</p> <ul style="list-style-type: none"> • Develop and test input interface • Develop and test output interface • Develop and test electronic enclosure • Develop HTML or CSS web page • Develop PHP and MySQL. 	<u>Teacher and Student Workbook AS2.8</u>
Students identify how they used information from trialling and testing to improve their outcome.	1 hr	<p>Teacher Workbook AS2.8</p> <p>Students create a heading Improvements and Refinements and add information.</p> <p>They read Stage 4: Development, Trialling and Testing: Make improvements and refinements</p> <p>Can students show instances where they used information from trialling and testing to make improvements?</p> <p>Students need to show more than one instance of improvement.</p>	<u>Teacher and Student Workbook AS2.8</u>

Specific learning outcomes (also can include what will be covered)	Duration	Learning activities	Resources
<p>Students discuss how the information from planning, testing and trialling of components assisted in the development of a high-quality outcome.</p>	<p>2hr</p>	<p>Teacher Workbook AS2.8</p> <p>Students create a heading Evaluation and Discussion and add information.</p> <p>They read Stage 5: Evaluation, Discussion</p> <p>Students need to, with help from the teacher:</p> <ul style="list-style-type: none"> • identify how their outcome meets the base specifications of the project • answer how their outcome addresses relevant implications • answer how the use of a develop - trial - test process enabled refinement of their outcome. 	<p><u>Teacher and Student Workbook AS2.8</u></p>

ASSESSMENT TASK: MONITORING WATER QUALITY – LAKE PROJECT

Curriculum key concepts	<i>DDDO: Progress outcome 5</i>
Achievement standard(s)	AS91891 Apply conventions to develop a design for a digital technologies outcome
NCEA Level	2
Credits	3
Learning time guidance	The task starts week 1 of term 2 and all portfolio evidence must be submitted by week 9 of term 2.
Length guidance if appropriate	Teacher to insert
Due date	Teacher to insert

Achievement criteria

AS91891

Achieved	Merit	Excellence
Apply conventions to develop a design for a digital technologies outcome.	Apply conventions to develop an informed design for a digital technologies outcome.	Apply conventions to develop a refined design for a digital technologies outcome.

ASSESSMENT TASK: MONITORING WATER QUALITY – LAKE PROJECT

Overview

This assessment activity requires you to apply conventions to develop a design for a digital technologies outcome. The outcome needs to be capable of electronic monitoring and storage of temperature data OR an alternative aspect of water quality.

Think about these questions:

How is water quality affected by natural conditions, seasonal weather and human impact?

How can water quality monitoring provide information on the state of water quality in the region?

What to do next?

Follow these steps:

- 1. Purpose & end-users.** Describe the purpose of the outcome and the requirements of the end-users
- 2. Design conventions.** Investigate and apply design conventions related to system block diagrams, circuit schematics, scale drawings when designing your electronic system.
- 3. Relevant implications.** Explain relevant implications and how they will impact on your designs and final outcome.
- 4. Generating & modelling.** Generate circuit schematics for your system specifically the input, output and power subsystems. This means testing or checking whether your ideas are feasible, checking that end-users understand how your system will function.
- 5. Select & Justify.** Select a design for the purpose of the outcome and explain the appropriateness of the design in terms of usability, functionality, physical size and shape etc.

How you will be assessed?

Use the following as a checklist for the assessment:

- Develop a design (Achievement): you are required to show evidence of each stage 1-5 within the design process as outlined above.
- Develop an informed design (Merit) means using feedback gained from modelling to improve the design, explaining how the chosen design uses appropriate conventions and showing within your designs that you have addressed relevant implications and end-user considerations.
- Develop a refined design (Excellence) means justifying how the chosen design addresses implications, end-user considerations, and uses appropriate conventions.

ASSESSMENT SCHEDULE

AS 91891 APPLY CONVENTIONS TO DEVELOP A DESIGN FOR A DIGITAL TECHNOLOGIES OUTCOME

Programme 8: Electronics - Monitoring water quality

Credits: 3

Final grades will be determined on a holistic judgment of the evidence against the achievement criteria.

CRITERIA	JUDGMENTS	COMMENTS
<i>Develop a design for a digital technologies outcome involves:</i>		
describing the purpose of the outcome and the requirements of the end-users	The student states the purpose of the outcome is 'to monitor water temperature in the lake' and is able to identify end-users and their requirements: For example, <i>local swimmers are keen to know more about the lake's temperature. Real-time temperature before a day's swimming and temperature over a long period of time.</i>	
investigating and applying relevant conventions	The student shows they have researched design conventions and their designs show the application of conventions such as: (1) system block – shapes, labels (2) circuit schematic – correct symbols, component designators and/or labels, title block (3) sketches – mockups show use of visual hierarchy or usability heuristics.	
generating and modelling a range of design ideas	The student generates a range of ideas such as: (1) system block diagram showing inputs, processes and outputs (2) circuit schematic with possible component options 'student shows thermistor and DS18B20 input interfaces' or 'student	
selecting a design for the purpose of the outcome and explaining the appropriateness of the design	The student is able to select a design based on requirements of project and explain the appropriateness of the design. For example, <i>a selection of input sensor or output subsystem with appropriate components. Students must also explain how the design is appropriate. For example reliability, robustness, costs of components, power consumption.</i>	
explaining relevant implications	The student explains, this means explaining the implications and their impact on the design of the outcome: 'Reliability is a key aspect in electronics, to work consistently and over long period of time. For this reason, the design of the power supply was much larger than needed ...'	

ASSESSMENT SCHEDULE

AS 91891 APPLY CONVENTIONS TO DEVELOP A DESIGN FOR A DIGITAL TECHNOLOGIES OUTCOME

Programme 8: Electronics - Monitoring water quality

Credits: 3

CRITERIA	JUDGMENTS	COMMENTS
using feedback gained from modelling to improve the design	The student gains feedback and uses this to modify (improve) the design: For example, <i>the teacher suggested the thermistor be wired to a digital pin to provide the ability to turn the sensor on and off. This will save power.</i>	
explaining how the chosen design uses appropriate conventions	The student can show how their design used correct circuit symbols, component designators. They can explain how visual hierarchy has been used to inform the design of the web page.	
addressing relevant implications and end-user considerations	The student's design work addresses implications and any end-user considerations. For example, <i>addressing how the user will interact with the system or addressing how the system will function in its intended environment.</i>	
justifying how the chosen design addresses implications, end-user considerations, and uses appropriate conventions	The student justifies by identifying aspects of the design and linking them to implications, considerations and conventions.	

ASSESSMENT TASK: MONITORING WATER QUALITY – LAKE PROJECT

Curriculum key concepts	<i>DDDO: Progress outcome 5</i>
Achievement standard(s)	AS91897 Use advanced processes to develop a digital technologies outcome
NCEA Level	2
Credits	6
Learning time guidance	The task starts week 1 of term 2 and all portfolio evidence must be submitted by week 9 of term 3.
Length guidance if appropriate	Teacher to insert
Due date	Teacher to insert

Achievement criteria

AS91897

Achieved	Merit	Excellence
Use advanced processes to develop a digital technologies outcome.	Use advanced processes to develop an informed digital technologies outcome.	Use advanced processes to develop a refined digital technologies outcome.

ASSESSMENT TASK: MONITORING WATER QUALITY – LAKE PROJECT

Overview

This assessment activity requires you to use an advanced development method to develop a digital technologies outcome. Capable of electronic monitoring and storage of temperature data or an alternative aspect of water quality.

This outcome must be capable of monitoring, storing and displaying data relating to selected aspects of water quality.

Think about these questions:

How is water quality affected by natural conditions, seasonal weather and human impact?

How can water quality monitoring provide information on the state of water quality in the region?

What to do next?

Follow these steps:

- 1. Project Management.** Use trello.com to set up and monitor tasks. Use file management / version control for software code during the development process.
- 2. Decomposition.** Decompose the outcome into smaller components for electronic sensing, data storage and data display.
- 3. Relevant implications.** Explain relevant implications and how they will impact on the development of the final outcome.
- 4. Development: Trialling & Testing.** Trial the components of the digital technologies outcome. Develop your outcome, testing that the outcome functions as intended.
- 5. Select & Justify.** Discuss how the information from planning, testing and trialling of components assisted in the development of a high-quality outcome.

How you will be assessed?

- Develop an outcome (Achievement) means you are required to show evidence of each stage within the development process as outlined above.
- Develop an informed outcome (Merit) means effectively using project management tools, correct file naming conventions to manage development, trialling multiple components and/or techniques and selecting those that are most suitable, using information appropriately from testing and trialling to improve the functionality of the outcome, and addressing relevant implications.
- Develop a refined outcome (Excellence) means discussing how the information from planning, testing and trialling of components assisted you in the development of a high-quality outcome.

Final grades will be determined on a holistic judgment of the evidence against the achievement criteria.

CRITERIA	JUDGMENTS	COMMENTS
using appropriate project management tools and techniques to plan the development of a digital technologies outcome	The student creates a Trello board and uses this to track and manage their to-do list for the project and file management / version control for software code.	
decomposing the outcome into smaller components	The student is able to decompose the project into smaller components to do, which may be focused on electronic sensor development, HTML web-page development or PHP and MySQL. 'Tasks are broken down into: build input interface, code and test functioning input data, validate input to check it is between acceptable values'.	
trailing the components of the digital technologies outcome	The student trials components in order to understand how the design works or to make a selection between two competing ideas: 'student trials DS18B20 temp sensor on a range of expected water temperatures, and trials sending data via radio link across a range of distances', or within web 'student trials navigation placement and layout using HTML elements', or with PHP 'student trials the querying of data from a MySQL database using sample code from W3SCHOOLS.COM'	
testing that the digital technologies outcome functions as intended	The student shows evidence of testing aspects of the outcome associated with its development, such as: testing that PHP and MySQL queries echo correct data onto page, testing the web page images, links and PHP scripts work as expected.	
explaining relevant implications.	The student identifies relevant implications and explains how they impact on the project's development. For example, <i>the student may explain the Health and Safety implications of installing a remote sensor over water, and explain appropriate safety procedures they will use when testing and installing on-site.</i>	

ASSESSMENT SCHEDULE

AS91897 USE ADVANCED PROCESSES TO DEVELOP AN INFORMED DIGITAL TECHNOLOGIES OUTCOME

Programme 8: Electronics - Monitoring water quality

Credits: 6

CRITERIA	JUDGMENTS	COMMENTS
effectively using project management and version control tools and techniques to manage the development of a digital technologies outcome	The student shows evidence of ongoing use of a Trello board to manage their to-do's. They are able to show clear versioning of development where appropriate (not all students will have a version 2) and use clear file naming procedures.	
triallying multiple components and/or techniques and selecting those which are most suitable	The student will trial components and select the most suitable. For example, trials of input sensor types or calibration of sensors, C++ code libraries for the DS18B20, or web-page navigation styles or data from the database displayed in tables or charted using chart.js. and have selected the most suitable component from the alternatives trialed.	
using information appropriately from testing and trialling to improve the functionality of the digital technologies outcome	The student has shown at least one or two good tests from which a result and some modification of the project occurred: student tested temp with actual thermometer and found sensor required 0.5 degree calibration, or student tested system over a week and found the batteries dropped below minimum voltage, so used deep sleep states to lower power consumption, or student interviewed stakeholders and used information to show the siaply of data on the web page.	
addressing relevant implications	Within development, it is possible to see that the student has addressed implications.	
discussing how the information from planning, testing and trialling of components assisted in the development of a high-quality outcome	The student discusses how planning enabled their outcome to be completed in a timely manner, without the need for constant teacher guidance. They discuss trialling and testing and can identify specific trials or tests that they conducted and how the results led to refinement.	