Data Loggers Project – Activity Plan

Introduction

The National Laboratories Public Engagement group intend to develop resources to engage families with STFC science and technology, with a focus on those living within the 40% most deprived areas of the UK as part of the STFC Wonder initiative. There are significant barriers that limit the ability of families living within these regions to engage with our programmes and undertake hands on public engagement, particularly in the current COVID-19 climate when most engagement has moved online. This project aims to develop 'Wonder Packs' that can be distributed to families living within these regions, enabling them to undertake scientific investigations that introduce STFC science and technology and that also encourage the development of coding, engineering and 'Working Scientifically' skills. The core element will be a 'build and code it yourself' data logger that will be utilised by families to undertake their investigations.

Software

The ability to code and utilise these data loggers to engage children from an early age will increase the likelihood of success for this project. Our aim is therefore to ensure that the software and hardware involved will enable children from the age of 8 onwards, with some previous knowledge of Scratch, to pick up, code and engage with the projects that we set.

By the age of 8, children following the National Curriculum in schools will have been taught to:

- understand what algorithms are, how they are implemented as programs on digital devices, and that programs execute by following precise and unambiguous instructions
- create and debug simple programs
- use logical reasoning to predict the behaviour of simple programs
- use technology purposefully to create, organise, store, manipulate and retrieve digital content
- recognize common uses of information technology beyond school
- use technology safely and respectfully, keeping personal information private
- identify where to go for help and support when they have concerns about content or contact on the internet or other online technologies.

Between the ages of 8 to 11 years, children following the National Curriculum in schools will be taught the following:

- design, write and debug programs that accomplish specific goals, including controlling or simulating physical systems
- solve problems by decomposing them into smaller parts
- use sequence, selection, and repetition in programs
- work with variables and various forms of input and output
- use logical reasoning to explain how some simple algorithms work and to detect and correct errors in algorithms and programs
- understand computer networks including the internet; how they can provide multiple services, such as the world wide web; and the opportunities they offer for communication and collaboration

- use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content
- select, use and combine a variety of software (including internet services) on a range of digital devices to design and create a range of programs, systems and content that accomplish given goals, including collecting, analysing, evaluating and presenting data and information
- use technology safely, respectfully and responsibly; recognise acceptable/unacceptable behaviour; identify a range of ways to report concerns about content and contact

Project Aims

There are four critical elements to this project:

1. Keeping the cost down to a minimum to enable us to engage as wide an audience as possible
2. Ensuring that any coding can use block based interfaces to make it as accessible as possible
3. Having a solution for Wonder households who do not have access to screens / laptops / tablets / input devices (the Children's Commissioner estimated that approximately 9% of families do not have a desktop / laptop / tablet)
4. Having enough (and the appropriate) sensors associated with the data logger to enable users to tackle a variety of STFC themed STEM investigations

The brief

1. Develop a data logger that can be assembled, coded and utilised by children aged between 8-14 years. Utilise components that are low cost to source, require only basic assembly by the user (appropriate for the age range stated), and incorporate sufficient sensors to undertake a wide range of indoor scientific investigations.
2. Ensure that the data logger can communicate with and be controlled / coded by a variety of devices, including computers that run windows or Linux based distributions, and ideally smart phones and tablets running iOS and Android.
3. Develop a low cost solution to enable users who do not have access to computers / laptops / tablets and whose households are on limited 'data packages' to interact with, code and control their data loggers.
4. Develop / utilise a block based coding software package that will enable the user to adapt existing code or develop new code to set up and control how their data logger will record data using the different sensors available to enable them to undertake scientific investigations.
5. Ensure that all data collected by the data logger can be accessed through the download of data as .csv files, or the upload (automatically or otherwise) of data online to a service that provides graphical readouts of the data produced.

6. Beyond learning how to code and physically use the data logger to collect data, the data loggers should also offer three broad and overlapping engagement opportunities based on age and ability:
    a. Children should understand that data loggers can sense different variables; the data loggers must provide opportunities for children to explore different variables and discover how values associated with each variable can 'vary' up and down.
    b. Children should understand that data loggers can collect data about specific variables and that these values can vary based on changes in other variables; the data loggers must provide opportunities to explore how one variable might change due to other measurable changes to the local environment.

c. Children should understand that data loggers can be used test scientific theories or demonstrate scientific models: the data loggers must provide opportunities to both manually and automatically collect, store and display data to enable children to investigate both their own, and pre-set science activities.

Provided Materials

- Project Brief (this document)
- Python Example Code
- Scratch Example Code

Exploring different variables

1. It would be great for children to use existing / create new scratch avatars and then have the ability to make their avatars react to the changing values received from each of the sensors (eg changing colour / size / behavior / movement / speech bubbles) based on changes in the input received from a sensor
2. It would similarly be great to use existing / create new backgrounds which can also react to changing values from each of the sensors (eg pictorially changing scenery to reflect temperature changes / humidity changes / light changes)
3. We want to make the scratch environment as visually appealing as possible. A big part of this project is about sharing with family, so being able to display things visually is very important. So creative ideas for simple to read graphs would also be very useful.

Exploring how variables change over time

4. It would be great to have scratch blocks that can:
    a. 'Command' each individual sensor (and include a clear image of that sensor if possible)
    b. Provide read outs for the values received from the sensor
    c. Change the precision of the values received from the sensor
    d. Change the frequency with which you 'see' values received from the sensor
    e. Switch between manual data reading and automated data reading
    f. Provide 'Time stamps' to define when to start and stop taking measurements
5. It would be great if all of the above can be used to change the avatar / backgrounds as expressed in 1. and 2. Above
6. It would be great to have an interface to display the sensor readings (eg a cartoony picture of a data logger displaying the data being collected)

Investigating Science theories and models

7. It would be great to have a scratch process that would allow us to:
    a. automate making graphs (bar / scatter / line graphs / pie charts)
    b. create a CSV file with data collected
    c. Send a csv file to Libre Office / Microsoft Excel and that ensures that the file opens with data in usable tablature form
    d. Update a csv file automatically as more data is collected
    e. Upload data to a location on the cloud

Additional Guidance

- There is a balance between sourcing the right choice of components for the cost envelope. £50 or less per data logger pack is ideal, however £100 or less per data logger could also be viable.

- Assume that households have access to at least one smartphone device and a TV screen with HDMI input, although access to these devices will be limited.
- Assume that households will have WiFi or Mobile data access, although it is likely that the amount of 'data' available is limited.
- Assume that children have the ability to upload data in schools.
- Assume limited technical knowhow and confidence – the target audience is children aged 8-14 (and particularly children at the lower end of this age range). These children will have familiarity with Scratch.
- Consider use of the Internet of Things.
- Resources linked to the actual investigations that families undertake have not been developed yet, and therefore a variety of sensors to enable new investigation ideas is essential. Families should also be able to explore new projects for themselves, after having gained familiarity with the hardware.
- Consider the use of Raspberry Pi (zero / 3 / 4 / 400) and/or Arduinos. Consider readymade sensor boards / hats / shields as well as individual sensor components. Farnell have access to better pricing for Raspberry Pi and we might be able to get preferential prices.
- Consider readily available block based coding solutions (eg scratch / ardublock).