The Gnome Project: Connecting the Community & the Classroom with Project Based & Outdoor Learning

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Abstract
We present a platform and sensing platform that allows school children greater involvement in their wider community, promoting the learning of design and computing. The system has three distinguishing features; it's easily hacked (both hardware and software), provides an increased awareness of environmental issues and 'real world' scenarios, and promotes learning engagement to both those inside and outside the classroom.

Introduction
Project based and outdoor learning with a cross-curricula approach to education has been argued as a highly affective approach in bringing contemporary pedagogy into the classroom. In contrast, the education system in the United Kingdom generally has well planned structures, systems and researched pedagogies in place to help support the learning and development of young people from the ages of 4 – 16 years. However, these structures and systems can be viewed to be formal and rigid that can negatively affect teachers and pupils.

To address these concerns, educators are constantly seeking novel and personal engagement methods to ensure learning is fun and warrant that wellbeing is at

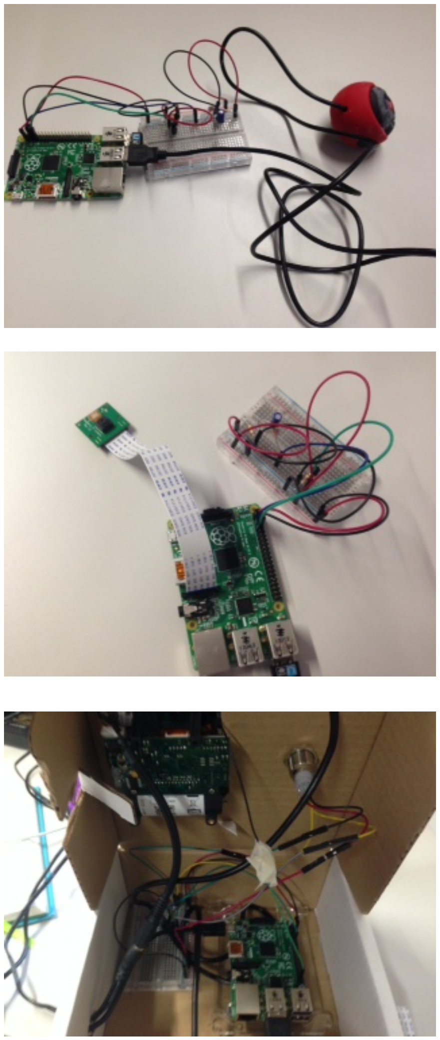

Figure 1 – How the gnome electronics developed (above) & the printer electronics

the core of the activity. One such approach is Outdoor Learning where children are physically taken in spaces outside their classroom environment to learn their curriculum. Academic rhetoric indicates that outdoor learning encourages physical risk-taking in young people [7] and encourages better motor fitness and creativity in young people [1]. Increasing environmental concerns has also raised the profile of outdoor learning to help young people develop positive and caring attitudes to the their environment [7].

Educators are keen to embed this form of learning and are seeking technologies that help them connect better with the environment around them. [9] [2] [3] [5]. Concerns about health and safety if there are special needs children, teachers' lack of confidence especially if they are new teachers, shortages of time, resources, support has restricted implementation of this learning method in schools [4].

'The Gnome Project' is an effort to act as a bridge to initiate schools alongside encouraging them to consider outdoor learning approaches within their curriculum. The project is designed to develop learning from the 'bottom-up', and where young people can become co-producers of their learning by engaging at all levels from implementation of the project, writing software, wiring hardware, and commissioning a project within their community. We were keen to support the cross-curricula approach and thus have accommodated lessons to contribute into subjects including computer science, biology, art and design and geography. "Skype Grannies" have shown us that figures in the community have a desire to engage with classroom activities. We wanted to harness this in a similar way, and connect the classroom to activities and individuals active in their communities, benefitting from the learning opportunities presented there and thus have shaped this particular project to build intergenerational links.

The Gnome Project

From this rational, we present 'The Gnome Project' as a project school children can implement and engage with. 'The Gnome Project' is a template and framework for a digital garden gnome, situated in a community garden or allotment. Although this report will focus on a garden as the natural 'home' for a digital gnome, you could equally imagine such an artefact in a similar community setting (such as a library or shop, as will be discussed).

The project is made of three elements; the gnome, the printer, and the web platform. The gnome collects sensor data and feeds it back to the classroom via 'The Toadstool', the online hub collating data from all gnomes currently deployed. Gnomes are also fitted with a webcam, keeping track of activity happening from within the garden; essentially giving young people an active 'window' into the garden. Separate printer hardware enables young people to communicate with those looking after the garden via 'The Toadstool', allowing and gardeners to reply at ease to these questions or suggestions via text message, which are then returned to the young people in the classroom. This effectively allows young people to have an active 'voice' within the garden.

'The Gnome Project' also provides an exciting opportunity through online social media. The gnome tweets notable activity on the sensor data and interactions between young people and the garden. This enables young people to have a safe and meaningful interaction with social media from within

Figure 2 – The Prototyping process from low to high fidelity

the classroom, along with enabling a digital presence for those who may not otherwise engage with social media through a situated technology. We believe that this has resulted in a powerful combination of ubiquitous technologies in a community-learning project.

Hardware

The hardware of 'The Gnome Project' comprises of two parts: the gnome and the printer device**.**

Gnome Components

In developing the hardware for 'The Gnome Project', it was important for us to make the hardware as accessible as possible for school pupils. To this end, the gnomes are easily modifiable from the template we provide, allowing students to add sensors and components to respond appropriately to their environment. The main components of 'The Gnome Project' are two Raspberry Pi single-board low-cost computers, originally designed as an educational tool.When selecting the devices to attach to the Raspberry Pi in our prototype gnome, we took care in striking a balance between components that provide quality data alongside adequate simplicity. In experimenting with different devices, we found the camera board (designed to attach to the Raspberry Pi) the most desirable for accessibility and image quality.

Likewise, it was desirable for us to strike a balance in our choice of sensors for the prototype. This is where 'The Gnome Project' is most obviously 'hackable' – students would be able to add as many sensors as they wished to the gnome to collect relevant data, even a full weather station if they wished. However, in our prototype, we selected a thermistor (providing temperature readings) and a photoresistor (providing light level readings) as inputs. These sensors are simple to wire to the GPIO pins on the Raspberry Pi, requiring only power, grounding, resistance and connectivity to one of the pins. The photoresistor required a simple capacitor to translate the analogue signal into a digital input. We felt these principles were simple enough for a school-based audience, but also provided meaningful data (and effective data visualization – see web software). They are assembled on a prototyping breadboard allowing them to be easily understood and modified.

The sensors play a key role in the rationale behind the project. Students are able to use the sensor data to monitor the garden and provide advice, ask questions, or more broadly start a dialogue with people involved with the garden. This also serves a role in providing an environmental educational agenda.

Printer Device

Although more complicated to wire, the printer device is a modified component for ease of implementation. The device plugs into the USB port, however there is also a lighted button wired within the same system which indicates when there has been a new question posted and prints it when pushed. A transistor is also used, as the bulb requires 5v to illuminate adequately (compared to the 3.3v output of the GPIO output pin). Like the gnome, this is wired in via a breadboard for simplicity of implementation.

In early versions of 'The Gnome Project' we had a screen on the front of the gnome. However, after prototyping different versions (see below) this proved impractical. In an ultimate version of the gnome where

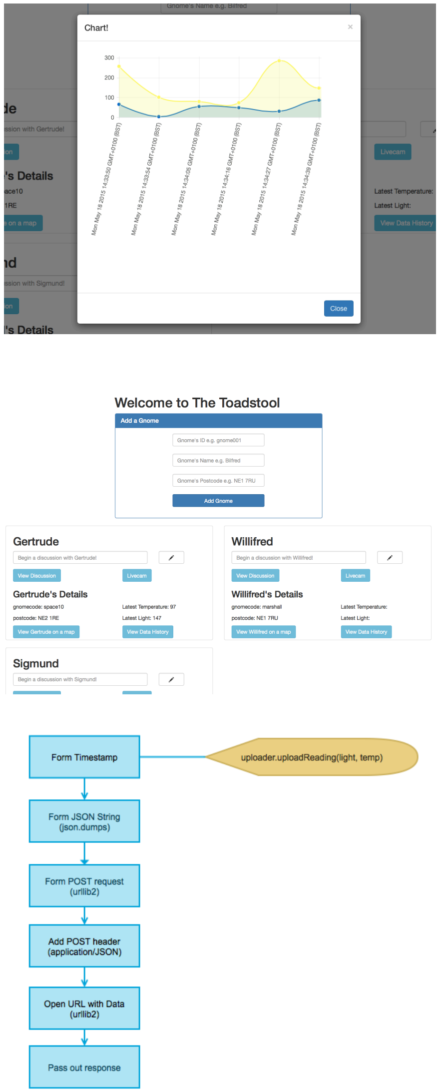

Figure 3 – The Toadstool Interface

components were waterproofed a screen would add unnecessary complications, and mean the gardener would have to go outside to receive questions. It was also foreseen that there would be an unpredictable rhythm to the dialogue arising from the classroom. Therefore we saw a printer as a practical and playful solution to this problem. Since it was our aim to facilitate engagement from populations who may not be particularly ofay with digital technologies, we saw particular charm in making the interactions physical - arriving from the classroom in print. It was also thought that by having print-outs mounting up, communities may feel more inclined to join in the dialogue.

Fabrication

We developed a simple laser cut template as a housing for the all hardware – equipment commonly available in schools. The two pieces of hardware went through several stages of prototyping (outlined below), with the final design being shared alongside the code for easy fabrication and modification. The templates include recesses (two panes cut from plywood) and mortise and tendon joints (to give the 3D structure) – giving strength and simplicity to the hardware casing. This also enabled the electronics to be housed easily and simply, facilitating them to be easily modified or altered if needed.

The materials for the casing were deliberately kept simple. The only requirements are; 1x 3mm thick sheet of plywood or acrylic, 13x M2 screws & bolts and 12x M1 screws and bolts.

We went through a series of prototyping with the gnome and the printer, from a low fidelity 'mock up' using cardboard and craft materials, to a clay model, to various versions of our laser cut design. Through this, we developed a template that is optimal to the size of the components inside. For example, through making multiple versions of our laser cut design, we were able to affix our electronics more efficiently and reduce the thickness of each artefact. We offer this laser cut template on our wiki if schools wish to use a premade version of the gnome. However in the cross curricula spirit of the project, we would encourage schools to use the insights from our designs to develop their own designs.

Software

Each piece of hardware is paired with software written for the individual operations of the device.

Web Interface – The Toadstool

'The Toadstool' was developed through discussions on how multiple gnomes can be deployed and visualised by a team. The notion of a control hub that collects all of this information together was agreed as an appropriate response to this challenge. In order to maintain a simple layout, and prevent the users from needing to navigate a number of pages, modals [Figure 3] were integrated in order to display the various pieces of information provided by each Gnome.

SMS (via Twilio – a cloud-based text messaging service) "texting" was chosen as the primary method of receiving communications from the community users as it integrates well with multiple types of users and did not require the use of a smartphone or familiarity with a web service. Mobile phones are usually on hand, and SMS is widely available. Since the information from the message is simply passed onto the Gnome web service,

Figure 4 – Incorporation of data into Twitter interface

the use of the Gnome is not predicated on the Twilio service and replies can be solicited by any means deemed appropriate by a team deploying gnomes, instructions on the project wiki reflect this capability.

The Twitter Bootstrap CSS template was used for ease of navigation. The sensor data was translated into a simple graph for ease of data visualization. The temperature and light data fit well together in a graph, so young people can see how they correlate and understand trends emerging from the data.

Raspberry Pi Software

In order to promote the 'hackable' nature of the Gnome, a number of helper classes were written in Python to abstract some of the more technical details of connecting to the webfrom the main Gnome scripts. An example is shown in [Figure 3], where the task of compiling JSON encoded data and forming a HTTP POST request with it is abstracted into a single method of "uploadReading" which can be called from anywhere in the main script. With these abstractions, the main script becomes instantly customisable by the user as they can use the Gnome's existing functionality how they want by simply utilising the provided classes as needed. Furthermore, an example tutorial was written into the Project Wiki on how to write additional functionality into the Gnome by editing the helper classes, should the user wish to.

The 'baseline' code (which could be added to) comprises of two major parts. The raspberry pi inside the gnome itself runs two programmes, one monitoring and sending sensor data from the GPIO pins and one taking a picture and sending it from the camera module. We worked to send the sensor data at frequent enough intervals to give an accurate real time representation of the data, but infrequent enough for effective data visualisation (every 10 seconds for both sensor and camera data). Sending the data for the sensors and the camera, and receiving information from 'dialogue' sent through the server is enabled through the pre-written python classes.

Incorporation of Twitter

A key aspect of the project is enabling the Gnome to interact beyond the confines of the classroom. We wanted to build on this aspect and explored using Twitter in the project to facilitate wider exchanges. We have currently enabled two interactions to be projected within the Twitter feed, Gnome-initiated tweets (tweeting temperature of the day) and specific exchanges between the Gnome and the web-interface (tweeting the questions put forward by the students). This is to done to help provide a framework and with creativity, users could adapt this to their needs and requirements. We wrote software on the Raspberry Pi to facilitate tweeting at certain intervals. Care was taken to make sure that tweets were regular enough to make the twitter feed look 'alive' while not overwhelming. Moreover, we used Python logic to give personality to these tweets – for example keeping track of the highest and lowest temperature data, enabling personable and fun tweets.

Conclusion and Further Applications

We present 'The Gnome Project' as both a project that stands alone as a working prototype, yet also offers opportunities for adaption and creative play from within the classroom. To conclude, we discuss potential further directions and applications to the project framework outlined in this document.

Figure 5 – The final gnome and housing of electronics

Recent literature has highlighted the benefits of using gamification in learning settings, through stripping out principles from gaming (for example leader-boards) into classroom settings [6]. In this way, we see clear application of gamification principles to 'The Gnome Project'. One could envisage for example different children in the classroom taking ownership over a gnome in different gardens, and competing against each other through giving advice to their individual gardens. This would provide additional motivation for engaging within this community project.

Additionally, one could envisage different scenarios where situated artefacts of this kind could benefit a classroom with community learning. Situated devices such as these could be deployed in another community space such as a workshop to encourage learning around a specific area of interest. We would see this as an opportunity to vary both what the device senses, and the characteristics of the artefact itself (i.e. alternatives to a Gnome that may be more fitting to that specific environment). Ultimately we would encourage young people to adapt this technology in a suitable and meaningful way according to individual contexts.

Although still in prototype form, 'The Gnome Project' provides a powerful framework in which to apply project based and outdoor learning, connecting the community and the classroom into a meaningful digital artefact. A clear future step for this project would be to offer the principles from our development for young people to appropriate in their own r community circumstances.

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Personal Contribution to Project

Alexander Wilson

Coding

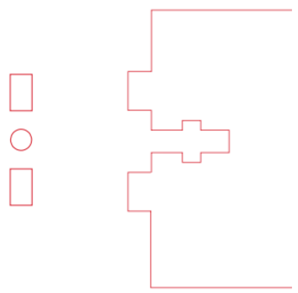
I was primarily in charge of developing the code for the printer. The printer has an associated Python library to operate it, but required significant reworking for it to work with our question receiving script. I developed my understanding of Python by interfacing with web-servers to receive questions, as well as hardware using USB libraries and electronic components. I also used the Tweepy library that allows the printer to Tweet the dialogue after they've been printed.

I setup the server for the project, and coded the website though learning to use Twitter's Bootstrap CSS templates. I developed the php side of the website, which allows users to update a file with questions for the printer to then receive.

Fabrication

I developed a deep understanding of both how the laser cutter works, and, how to exploit its potential in the designs I created and the materials I used. I designed the hardware components (alongside Matt Wood) to achieve a design that required only screws and bolts, allowing it to be easily opened and modified.

This design enables pupils to make a gnome and a printer unit from a small piece of plywood and 8 nuts and bolts. There are also screw guides and holes for all the internal components.



Mortise and Tendon Joint

Content on Wiki/Report

Throughout the project I documented what I was doing on the Wiki allowing others to replicate the project and allow for easy hacking. I contributed to the report whilst writing up.