

# Model Electric Car – Outreach Project

Turning a model electric car into a school resource about batteries



Ben Dawson, Laura Wheatcroft, Max Yan, and Elinor Noble

## Abstract

We are developing a resource to teach schoolchildren about batteries in electric vehicles. The resource is a model electric remote-control car that displays the voltage across its motor and the temperature of the battery in real-time. Important parameters such as cell power and capacity are also calculated from these readings.

Students will be able to see how different factors, such as high acceleration and temperature, affect the performance of the battery. To make the resource interactive we have developed games that the students can play with the car which highlight problems such as increased weight or overheating.



## Motivation

**Lithium-ion batteries (LiBs)** are seen as a green alternative to powering vehicles but understanding how LiBs function in real-world applications (the underlying electrochemistry and parameters which affect performance) is a difficult topic to grasp for students and teachers alike. [1,2,3]

**Inspiring** the next generation of battery researchers is vital due to increasing demand on development in battery technology for high power applications such as electric vehicles.

**The model electric car resource** aims to add to the somewhat limited selection of educational resources surrounding rechargeable batteries<sup>[1]</sup>, to develop basic understanding of the electrochemistry of batteries and demonstrating how electric vehicle operating conditions – such as acceleration and temperature – can degrade battery lifetimes, and battery function.

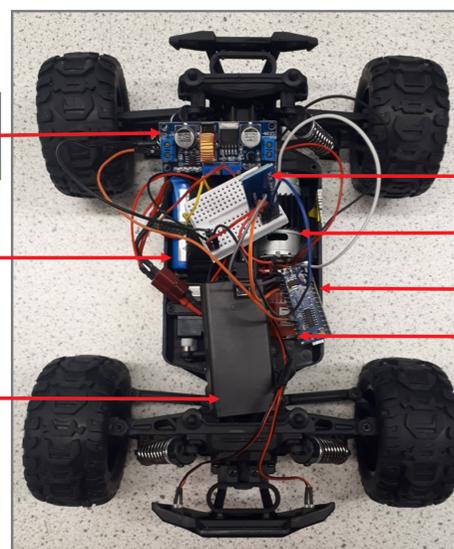
## How the Car Works

- An Electronic Speed Control (ESC) receives the remote control radio signals and modulates the voltage across the motor accordingly.
- A Lithium-Ion battery powers the car, and has a thermistor underneath to measure temperature.
- The voltage and temperature readings are measured by an Arduino Nano.
- The data is sent from the Arduino to the Laptop using an HC-05 Bluetooth module.
- A control panel displays the voltage and temperature readings, along with current, power and capacity

Voltage Modulator to protect the Arduino

7.4V 700mAh Lithium-Ion Battery to power the car. Thermistor is underneath this battery.

9V Battery to Power the Arduino



HC-05 Bluetooth Module

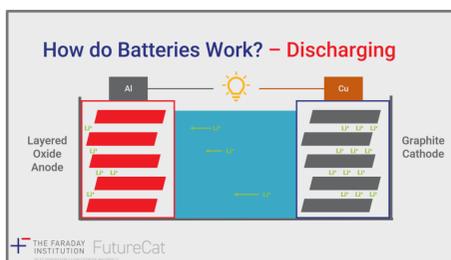
Arduino Nano

Motor

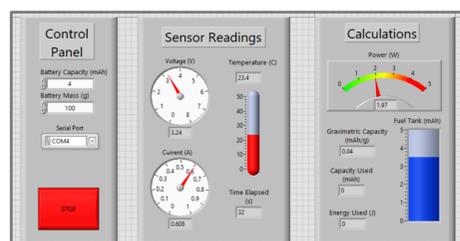
Electronic Speed Control (ESC)

## The Resource

- Whether presenting in a classroom or at a science fair the resource is designed to keep students engaged throughout. An initial short presentation comprises of two parts; **Why are Batteries Important?** and **How do Batteries Work?**

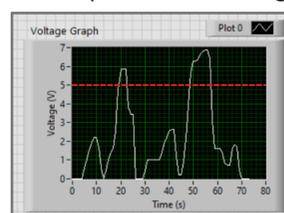


- The control panel (left) shows live readings so that students can understand changes in real time. The connection to the car is terminated by if the 'fuel' is drained, if the battery exceeds a certain temperature, or by the user.



## The Games

- **Vehicles Under Load** – This game involves students transporting weights across the classroom. A points penalty for the voltage going above 5V means they must trade off between the speed of each run and carrying a maximum load. There is also a penalty for the battery getting too hot. The game develops understanding of how general use can degrade battery function.



A point is deducted for every second the voltage goes above 5V

- **Don't Get Too Hot** – In this game the car battery will have been placed in the fridge, and the aim is for the students to do as many laps of a racecourse as possible before the battery gets back to room temperature. This game encourages discussion about how factors such as weather or cell overheating can impact battery function.

## Next steps

1. Make the resource completely user friendly by improving the Bluetooth connection. It can then be sent out to schools without the need for a Faraday representative to demonstrate and run it.
2. Build more cars to allow the resource to be accessed by a larger number of schoolchildren. If one could connect multiple cars to one laptop, then multiple groups of children could be playing the game at once, and the analysis could be done in a form of competition. This would make the material even more engaging.

## Impact

Developed a model electric car which demonstrates to secondary school students how cell voltage and temperature control are important factors in understanding battery function and longevity.

## References

1. *Journal of Chemical Education* **2020** 97 (8), 2231-2237
2. *Journal of Chemical Education* **1997** 74 (7), 819
3. *Journal of Chemical Education* **2002** 79 (6), 735

## Intern bio

Ben is studying chemical physics at the University of Edinburgh. Interested in science for a greener future, he is aspiring to work in a field where he can contribute to vital green technologies such as the battery research done by the Faraday Institution.

[Click here for Ben's LinkedIn Page](#)

