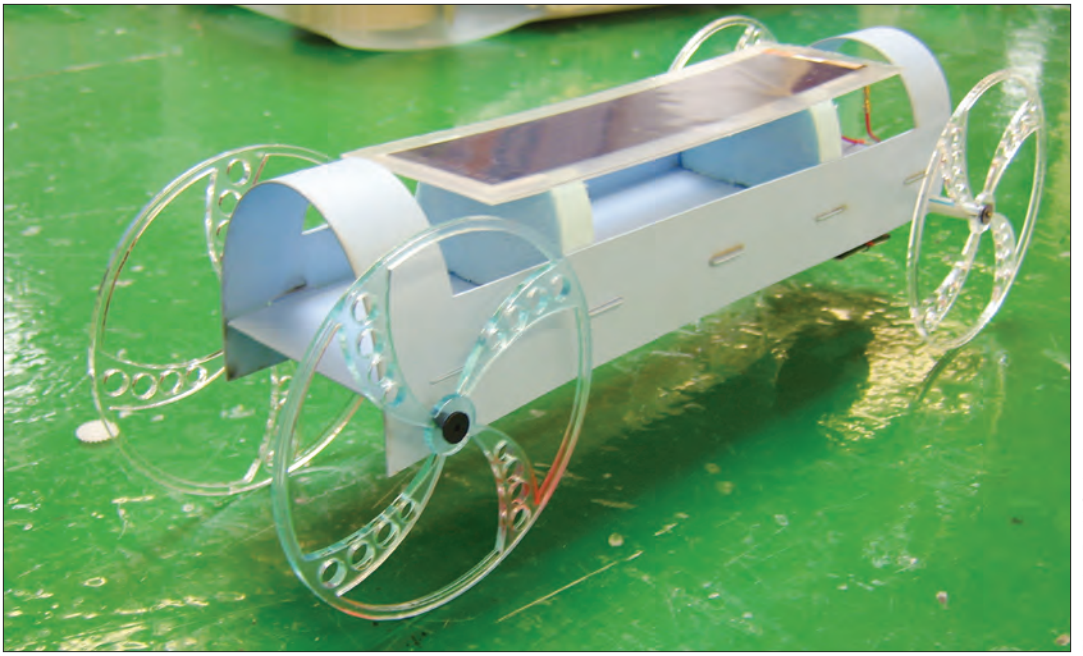
A Lean Green Sun Harvesting Machine

Making solar energy teaching more fun by using invisible forces to power race cars



Photographs: David Garlovsky

By **Mark Walker**

KAREN SHOWS ME the improvement she has made to her solar powered car; a tail fin made from aluminum. It is curved to reflect light onto the upper side of the car where the solar panel is situated. "But will this make the car go faster?" I ask. "How can you test this?" Karen thinks for a while, "maybe if I test the speed with and without the fin and compare which is quicker?" she suggests with caution.

The typical and rather abstract manner used to teach solar energy to children is with a diagram of a house with a solar panel on the roof. The problem is that electricity is 'invisible', it can't be touched or seen, and this makes teaching about it in a relevant and meaningful manner difficult. How can renewable energy teaching be made more interesting? How can something that is invisible be made visible to young students?

A solar powered model racing-car, developed by science educator David Garlovsky, offers one hands on option to make renewable electricity visible. Based in Sheffield, England, he promotes the cars in primary schools and colleges through the charity 'Solar Active'. He has been developing this teaching method for over 15 years, complementing the model car with an array of teaching lesson plans, student challenges and support material. The car is somewhat like a Meccano kit, as it comes in pre-assembled pieces that must be assembled by the students in order for it to work. However, unlike a Meccano kit, many of the components are designed with the surreptitious aims of teaching a variety of physics, math or environmental topics. What are the advantages of his car and how can it help in teaching science?

Generating Sparks: Making electricity visible

Children are not interested in how hot water systems work. But typically they are provided with the example of a water boiler in a house when taught about electricity and energy. This is because such a water heating system is analogous to how an electric circuit works. In both examples something 'flows' and energy, in the form of heat in the water system and in the form of electricity in the other, moves from one place to another. The problem remains, children simply are not interested in boilers and pipes and quickly lose interest.

But they are interested in motor racing. Racing cars move, and are a familiar toy that youth will associate with fun and they may not even notice they are learning while racing them. Solar panels on houses or pipes and boilers are static, and something their parents take care of. Attaching a solar panel to a model car immediately makes solar energy 'visible' as the electricity produced actually results in a visible effect. Students can see what the harvested electricity causes to happen. The lesson suddenly becomes relevant and entertaining. Most students experience travelling in cars every day, transit by cars (or other vehicles) is an important

part of their daily lives. The fact that renewable energy could actually be used in an everyday situation to replace fossil fuels becomes obvious and will be remembered for years to come thanks to the experience.

Tinkering

There is no set in stone assembly manual included in the box that shows how to put the car together. The myriad of features that can be manipulated and which influence the functioning of the car make it unique. Wheel size, solar panel elevation, car design, wiring, can all be altered. No two cars will end up exactly alike. Identifying and manipulating variables are key aims of science curricula between the ages of 11 and 16; skills utilised to the full with the kit.

Solar Active! works with teachers at Eckington School in the North of England. Teams at Eckington were provided with model car kits and charged a nominal fee to cover costs. These kits can be ordered from the website (details in the end credits). Alternatively similar kits may be available locally from similar organisations. Here, the car is used not just in a single lesson but for project work across the subjects of math, science and technology. Students work on the car for several weeks; gradually improving their design and looking at different aspects of how it works.

Start with a simple challenge:
'Design and build a solar racer using the kits provided. Test your cars and make modifications to improve their performance. Later they will be raced, and the best car will win.'

Some questions that may be asked, and you should be ready to address are:

- What influences the performance of the car?
- How do you decide which car is the best?
- How will testing be conducted? How will the races be conducted?

The kits contain all the components needed to manufacture a fully functioning solar car. These parts include a solar cell, motor, and all the usual parts of a model car such as a transmission, wheels and the supporting framework, the chassis, around which the car is constructed. Instructions and teaching aids are also included along with worksheets for students to complete. The kit allows students to design and make their own cars and provides an ideal introduction to solar energy use.

Although students are given instructions along with the separate components of the car, they have to decide for themselves how to put them together and which variables are important in determining the speed of the racers. Students can be prompted to consider the variables. What affects the speed of the cars? How can you make them faster? How can you compare speed between cars and between trial runs to determine what make-ups are the best? Are the same speeds obtained in every run? If not why not? How could you ensure you have the best features? How could you test the cars effectively? How could you record your results?

Harnessing the sun's energy

One variable students can be challenged to study for example is the angle at which sunlight hits the solar panel, a factor that influences how the solar panels should be mounted on the car. This placement influences the amount of energy the car can obtain from the sun. By concentrating on one single factor schoolchildren learn about manipulating variables in an experimental manner. Children have to decide how to align the panels. What angle leads to the most energy being collected and in turn makes the car travel the fastest? Children can experiment and try out different combinations, before deciding which angle of alignment is the most productive. The teacher can encourage students to take their understanding further and figure out why.

At Eckington the students have to design the experimental protocol or plan to work these things out. An experimental protocol forces students to think about what they wish to investigate and how they wish to proceed. It focuses them on designing valid experiments. The protocol asks students to define the variables, decide which should be altered and then what should be measured in order to find out how the angle of the panel affects the speed. Clever questioning by a canny teacher can elicit the required responses from the students.

One student in our trial quickly realised that although the panel could be tested at different elevations, everything else had to stay the same. It is no good testing a raised panel when the sun shines, but a lowered panel when it is cloudy; all other factors must stay the same if it is to be fair.

Green Engineering

STEM, the integration of science, technology, engineering and math in one single project to the benefit of all, is currently one of the most popular acronyms in teaching. But can STEM be used to teach environmental issues? Engineering and ecology seem somewhat incompatible.

Engineering, a main component of STEM, still evokes an image of a (male) with a smoke blackened face and oil spattered hands, eking an existence amongst a noisy and dirty metal workshop surrounded by various metal drilling tools. Does this stereotype have anything to do with green, seemingly technology absent environmental issues?

The Solar Active Racer combines engineering ideas with an environmental focus; vehicle propulsion using environmentally friendly energy. Students can actually see that there is an alternative to mucky non-renewable fuels. They can see first-hand that green fuels work. Another advantage is that this work widens participation to girls who may previously have been taught toy cars are for boys. Through use of the model they can see that they too can design cars, and may even create the winning model. In our experience, many girls were particularly drawn to designing the covering for the car, such as studying whether different outer coverings, wings, or added shapes will aid movement.

A key feature of the kits is that they coerce students to think about the factors involved in making the car run efficiently. Students have to take into account factors such as friction, how weight affects the speed of the car, and how the different parts work as a whole. Thus it entails the use of many relevant physics skills such as an appreciation of electrical circuits, motion, and efficiency. The key advantage of this method is that it introduces these theoretical ideas usually taught on the blackboard in a practical hands-on form.

Environmental Issues

At Eckington the car is used in environmental education, to teach about human effects on the environment. The teacher uses the car as a real example of a renewable energy source, when teaching this topic. Typically they start with discussing fossil fuels, where they come from, and what effect they have. Of course, students see this type of technology every day when driving around with their parents. But after working on the solar car, the teacher can provide a real (miniature) example of a 'green' car, and compare it with conventional cars. Suddenly students have an example they have seen first hand and built themselves. The idea of a 'green' car somehow does not seem as foreign anymore.

Despite the fact that everyday use of solar powered cars is a long way off, the importance of solar technology is shown. Ten photovoltaic panels have the potential to reduce the average household's energy needs by more than 30 per cent. The topic illustrates our attempts to find alternatives to fossil fuels. Conventional cars are a major source of greenhouse causing emissions, motor vehicles account for a quarter of all CO_2 emissions, burning one gallon of fuel produces 25 pounds worth of CO_2. Students learn through the lesson that trying to reduce this figure is a good starting point in attempting to reduce our overall effects on the planet.

The solar powered car shows one way in which this could be done. It could be used to open up discussion of other methods as well; such as electric cars, purchasing fuel efficient cars, and the advantages of reducing car travel and utilising other forms of transport.

Sustainable

The components of the kit itself are made up of recycled material; the plastic wheel arches are made from reclaimed credit cards, the wheels from old plastic bottle tops, wiring is retrieved from recycled electrical dealers, and the boxes the cars are delivered in are made from cut down card tubes previously used to package wallpaper. All of these recycled and reused parts make for a nice added bonus to the lesson. Conventional cars use an incredible amount of valuable raw material in their manufacturing, but the solar car shows there is another way. Students see how it is possible to use recycled material to make new products.

The challenge: Become a solar champion

Not only do the model cars make renewable energy visible, they also tap into children's competitive spirits. The lessons typically end with children conducting races, where teams compete with each other to see which has built the best car. As children are naturally competitive, the idea is to encourage them to ask, "Who can make the fastest car?"

The students at Eckington loved this part of the lesson! Races were conducted outside with students all lined up at a starting point to see whose car reached the finish line first to become a solar champion. All the cars set off together after a shout of one, two, three, go! The students decided that starting all the cars at once, rather than in heats, was the best way to ensure all cars had the same 'solar' conditions.

Inquiry can even be built into this part of the lesson. We asked students to develop the racing protocol, while asking them the following questions: Should races be conducted only once or should there be a series with the winner being the best overall? What distance should races be run over? Should all cars start at the same time or should they go one after another with each being timed? How can racing be made 'fair'? With questions like these the lesson can be made as open as required depending on the abilities of the students involved. As described by the creator, David Garlovsky, "It helps bring renewable energy alive in a way teaching from a book does not. Instead of learning about solar energy from the teacher they get the chance to build something sustainable themselves."

Mark Walker is a research scientist at Sheffield Hallam University in northern England and is passionate about getting people to realise how special our world is. He has published widely on inquiry-based science. He works for Solar Active helping promote STEM science.

Solar Active is a non-profit charitable organization dedicated to promoting solar and renewable energy through education. They work with many local schools, including Eckington School in Sheffield, to deliver project days. For more information or to order the kits visit http://new.solar-active.com/. Email David at: david@solar-active.com.