Bringing sports into the classroom

This teacher-training advert from the TDA shows kids learning the link between basketball and maths

If the 'leaning a ladder against the wall' example has failed to set your students' passion for Pythagoras alight, show them how maths affects something they love - sport! Professor **Adrian Oldknow** explains how PE is being used to get students interested in maths and science in Hampshire.

There's something elegant in the way physics, chemistry and biology knit together to build a complete picture of the way the world works. But it's not until one subject spills into the next that true understanding occurs of the way things work. In the same way that one branch of science inevitably links to another, so PE can link maths and science to the real world, and so enhance understanding. Moreover, such linking injects greater interest in sport participation itself, particularly for pupils who like to think academic subjects have nothing in common with PE and sport.

Hampshire LA's Pilot

Hampshire Learning Authority ran a two-year pilot project with five schools each identifying a maths, science and D&T teacher to work with other colleagues using ICT to stimulate cross-curricular work. The project was directed by Hampshire LA Maths Inspector, Ron Taylor, supported by Microsoft and TDA I was a consultant.

Henry Cort, is a Sports College where we were able to develop ICT based approaches for links with maths, science and D&T in sport. These have been carried forward into more specifically Science, Technology, Engineering and Maths (STEM) based activities in the region. Some of Henry Cort's work is featured on Teachers' TV at **teachers.tv/video/19119**. It was a case study for the Youth Sports Trust's "Raising Your Game" **ncetm.org.uk/files/360544/Raising+Your+Game+coresubj_070307.pdf.**

What sports can be studied?

The main activities investigated were throwing, kicking, hitting, jumping, firing etc. Technically these are forms of projectile motion, which was the basis of the study of dynamics (forces, acceleration, velocity etc.) which led to the discoveries and theories of Galileo and Newton. A simple example is throwing a small hard ball at angle. In order to find data about its motion we have three main techniques, each of which involves ICT:

● Measurement and modelling
● Data capture from sensors
● Data capture from video clips

Measurement and modelling

We can take measurements either by estimating, or with simple techniques like counting and pacing, or using instruments like protractors, tape measures and stop watches. For many sporting events, such as sprinting or track cycling, these are not accurate enough, so computer based measuring systems are used. Some games require judgment, eg to decide whether a ball, or a batsman, was in or out. The human line judge, referee and umpire is increasingly being supported by ICT based systems, such as the Hawkeye tennis system.

For a projectile we can measure the launch angle A°, horizontal range R m. and flight time F s. Assuming ideal conditions, such as no air resistance, spin or wind, and that the launch was from ground level, then the science theory states that the only force acting on the object after launch is that of gravitational attraction – so the acceleration downwards is g ms-2 and horizontally is 0 ms-2. From these, together with the ideas of speed as distance divided by time, and acceleration as change in speed divided by time, we can derive formulae for the motion such as H = R/F, V = H tan A,

g = – 2V/F and also find the position (x,y) at time t as x = Ht, y = Vt – ½ gt2 .

This use of algebra to find features of the motion based on scientific principles is called mathematical modelling. We can embed such algebraic formulae in a spreadsheet and so create a simulation of the ball's flight. Using mathematical software such as Geometer's Sketchpad, Cabri II Plus, TI-Nspire, Autograph – or graphical calculators or TI-Nspire handhelds – we can draw graphs directly from the measurements and calculations. These models can be used to predict behaviour for different launch angles, projection speeds etc. The predictions can be tested practically to see how the model matches reality. Note that this gives an experiment from which we can measure
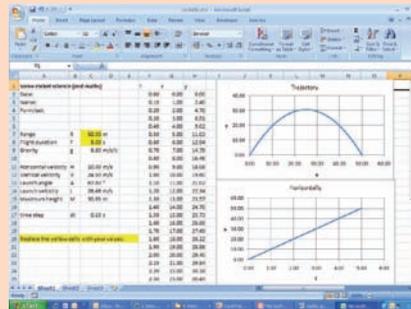

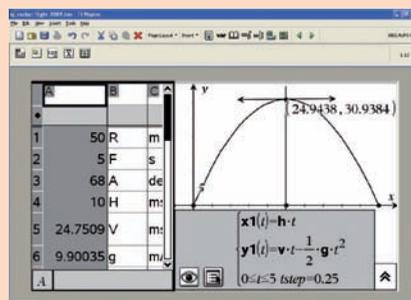Fig. 1 An Excel spreadsheet projectile
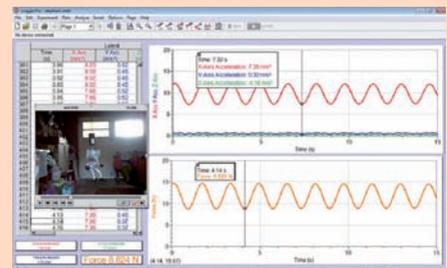

Fig. 2 A TI-Nspire projectile model

Fig. 3 Vernier's Logger Pro 3 and WDSS

Fig.4 Sciencescope rocket and Google

Data capture from sensors

A common system used in science for timing events involves light gates connected to data-capture software on a computer. Knowing the positions of the gates, and finding when an object passes through each, we can compute its average velocity. A range-finder, or motion detector, can measure distances to a given object in motion and be used to plot its distance-time graph, while also computing numerical approximations for velocity and acceleration. Such a sensor (CBR2) is shown in mathematics lessons on Teachers TV programmes

- KS3/4 New Maths Technology - **teachers. tv/video/154**
- Resource review: secondary maths 2 - **teachers.tv/video/4872.**
- Video clips of its use, and a lesson plan, can be downloaded from - **ncetm.org.**

uk/Default.aspx?page=14&module=com&mode=102&comcid=241&comf=40093&comu=0.

A more sophisticated approach uses one or more accelerometers attached to the object in motion - in this case a human runner, jumper, or cyclist. Once data has been captured it can easily be transferred into a spreadsheet, or software for data analysis such as Fathom or TI Nspire. TI Nspire handheld calculators and software support direct data capture from probes such as the CBR2 and low-g accelerometer. Another approach uses a wireless system, such as Vernier's Wireless Dynamic Sensor System, together with a Bluetooth receiver and laptop PC - **inds.co.uk/education/edusyswdss.htm.** Using this system strapped to an object, data can be captured and displayed in real-time. Another exciting development supported by Vernier's LoggerPro 3 software is to synchronise graphs of captured data with video clips of the experiment. So, for example, we can compare the acceleration of a sprinter leaving the starting blocks with video of the action.

Another fun idea is using a rocket logger - **sciencescope.co.uk/rocketlogger.htm.** The logger is a thin plastic tube containing three accelerometers, a pressure gauge, a timer and a battery. It can be charged up from a USB port, detached, attached as the payload for a rocket, launched from an Airburst rocket kit, recovered, reconnected and the data downloaded. The output can be data in a spreadsheet format (CSV) and/or a simulated video clip in Google Earth (KMZ). The data logging unit can also be strapped to an athlete or to a suitable piece of equipment, such as a javelin, although Google Earth output will not always be possible. Another possibility is opening up based on GPS technology - **vernier.com/probes/vgps. html.** Many of these approaches are suitable for

Data capture from video clips

Video analysis systems for use in sports have become relatively established in schools through systems such as Dartfish, Swinger and Kandle. The use of Dartfish with video capture of a badminton service in Arnewood College is another DfES video case study: **ncetm.org.uk/Default.aspx?page=14&module=com&mode=102&comcid=241&comf=40084&comu=0**

Here digital video from a camcorder is downloaded to Dartfish, where positions of the shuttlecock are annotated on successive frames. The resulting screen image is captured to the clipboard and pasted as the background in Geometer's Sketchpad over which graphs are drawn and manipulated to give good

Fig. 5 Video data capture from

Fig. 6 Video data capture with Swinger

mathematical models. The analysis is done in mathematics lessons, while the theory and explanations are done in science.
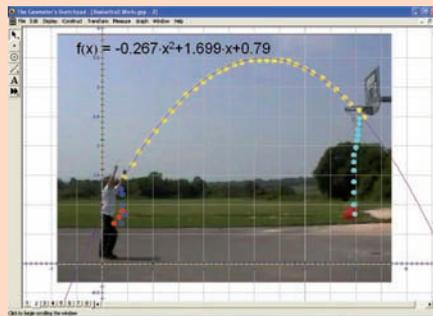

Fig. 7 Mathematical modelling with

The good news is that video data capture can be achieved using relatively cheap devices such as the video mode on digital cameras and/or phones or cheap video devices like Disgo (under £30). There are low cost science packages such as Vernier's Logger Pro 3, which support video data capture, but there is also open-source free US software! Henry Cort used the Vidshell package developed by Doyle V. Davis, which you can download together with a library of video clips from: **webphysics.ccsnh.edu/vidshell/vidshell.html.**

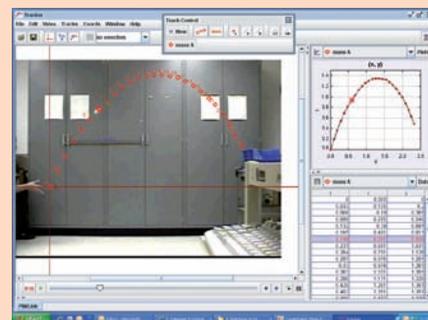This is used with a screen shot to capture an

Fig. 9 Video capture with Vidshell

annotated image of the position of a basketball as the background for analysis in Sketchpad.

Fig. 10 Video capture with Tracker 2

As part of a QCA project "Engaging mathematics for all learners", Teachers TV has filmed pupils from Wildern school undertaking a playground project in which they also use video analysis. They use Tracker 2, a free Java applet from Doug Brown: cabrillo.edu/~dbrown/tracker/. With Tracker you import a video clip, calibrate it, overlay axes and record data while tracking the position of an object. While the video is being annotated in one window, a table of data is generated in another, and a graph in the third. All the analysis and modelling can be done within Tracker itself. At Wildern a group of Year 10 students produced a DVD of their project which includes a section demonstrating how to use Tracker: ncetm.org.uk/files/362726/Wildern+clip+2.avi.

When filming motion it is important to keep the camera still, and not to track the object, nor to zoom. Normally the motion being studied only requires a few seconds of video, so access to editing software is useful. Some formats may not be readable, so video conversion software can be useful.

Other possibilities

This article has concentrated on moving objects – which can include pupils doing sports and PE. Of course there are plenty of opportunities for ICT use to study the impact of exercise on pupils. Sensors such as heart-rate monitors, temperature probes, balances, pressure pads, force gauges etc. can be used to measure aspects of performance. Another related field of study is biomechanics – which concentrates on the geometry of the human frame – which can be modelled using CAD and geometry software. Another concerns the properties of new materials developed for sports clothing, such as swimwear. Yet another is concerned with the design of the apparatus used for sports such as cycling, rowing, sailing, skiing, archery etc. So clearly the field of PE/sports is a rich source for ICT assisted cross-curricular project work – especially for the STEM subjects.

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