Graphing with palmtops

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Portable technologies are becoming increasingly popular in schools for a variety of reasons: they offer tremendous flexibility; increased access to IT and significant practical advantages over conventional desktop computing; personal ownership and opportunities for more independent, investigative learning across the curriculum; improvements in the quality of work produced; increased pupil motivation, and so on (see review by Hennessy, 1997). In particular, portable graphing tools – palmtop computers and graphic calculators – present a unique opportunity to help students develop understanding and skills in a traditionally difficult curriculum area. Our research at the Open University focuses on exploiting the potential of these increasingly cheap and powerful tools in helping to develop understanding and skill in graphing in secondary school pupils.

In this article we report a series of trials of a graphing activity devised for the Acorn "Pocket Book" computer [1] in a Buckinghamshire comprehensive school during 1997. The aim was to investigate the advantages and disadvantages of working with palmtop technology to explore the relationship between two variables: height and shoe size. We began with year 8 children who had all used the Pocket Book spreadsheet once before to produce a bar graph during an activity involving preparation of a budget for a party.

The teacher collected a set of data from the group and recorded it on sheets for circulation. His rationale for collecting the data in advance was that data collection might prove chaotic and time consuming with this rather unruly group; as the lesson was short (50 minutes, with some time spent on issuing and collecting Pocket Books), this was quite sensible. To emphasise the trend in the data, 20 sets of measurements were provided; these came from 4 pupils randomly selected from each of four different year groups, and from 4 teachers (Figure 1). The pupils' task was to enter the data into the Pocket Book spreadsheet and to plot a graph of shoe size against height. Basic commands for producing a graph of two variables were provided (Figure 2). The researcher and teacher offered further technical help. The 22 pupils were seated in pairs and, although each had their own machine, they were encouraged to collaborate on the activity. As is often observed when pupils use portable computers, they spontaneously discussed the activity with their partners and with other pupils too.

A problem experienced was that the graphing facility on the Pocket Book does not work intuitively to graph two variables against each other. Points within such a graph cannot be connected (unless the data is originally entered into the spreadsheet in order of increasing magnitude). Nevertheless the activity proved very successful in that almost all pupils produced a coherent graph showing a visible linear trend during the 50-minute lesson, despite limited prior experience and having to use a new set of commands. Most pupils also sketched their graphs with reasonable accuracy using the axes provided (see Figure 3) and answered some of our written worksheet questions, although they ran out of time and little discussion was possible. The pupils were generally able to identify the trend of height increasing with shoe size.

Dealing with a large amount of data proved problematic in the sense that errors arose in copying the data down or in entering it in the correct rows of the spreadsheet; some children did not line up the names, shoe size and height correctly. Discussion between groups of pupils and the researcher or teacher helped to clarify the demands of the task where necessary and the children's views about the activity. However, the children recorded little of what they had discussed – a common problem with investigative classroom activities and one that is difficult to overcome. Some worksheet responses from a more prolific pupil are shown in Figure 4. The children needed quite a bit of help in finding the right commands on the Pocket Book to achieve the desired effect. Some pupils went beyond the demands of the task to label their axes, graphs and data points.

	Name	Year	Shoe size	Height in metres
1	Kelly	8	3	1.56
2	Amy	8	4	1.57
3	Kieran	8	4	1.50
4	Paul	8	6	1.61
5	Michael	9	8	1.70
6	Ben	9	10	1.76
7	Amy	9	7	1.72
8	Charlotte	9	9	1.77
9	Donald	10	9	1.73
10	Andrew	10	11	1.82
11	Gemma	10	7	1.75
12	Jennifer	10	6	1.65
13	Anna	12	7	1.75
14	Debbie	12	5	1.68
15	Tom	12	9	1.81
16	Geoff	12	8	1.72
17	Mrs Cuttress	teacher	5½	1.68
18	Mrs Bennett	teacher	4	1.64
19	Mr Northern	teacher	12	1.93
20	Mr Thomas	teacher	9	1.79

Figure 1

Pocket Book commands for line graphing

1. **Menu** button; **Special** menu; choose **Graph**

2. **Display** menu, choose **Format**, choose **XY/scatter**

3. **Ranges** menu, choose **Set ranges**;
   set Graph range **A**
   Enabled: **Yes**
   Range: **C2:C21**
   Repeat procedure for Graph range **X**, setting range to **B2:B21**

4. **Ranges** menu, choose **Set line format**;
   set Graph range **A**
   Show lines: **No**

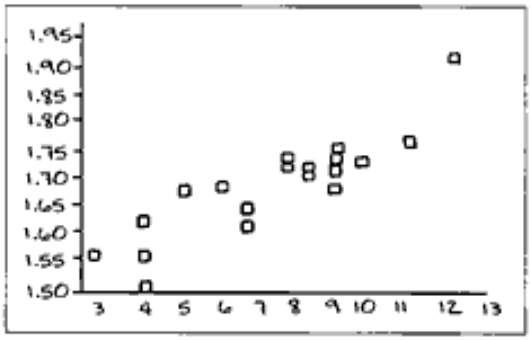


Figure 3

What conclusions can you draw from your graph?
The taller you are the bigger the shoe size you have

Are there any data points which don't seem seem to fit in very well?
There's someone with a size 9 who's taller than some one with a shoe size 8.

What additional data would be useful? Who could you get this extra data from?
We could go to a middle school and get their height & shoe size

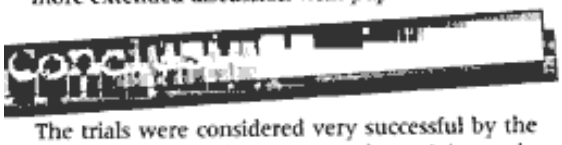
What shoe size is a person who is 1.2 metres tall likely to take? 1

What about a person who is 1.7 metres tall? 9 or a 5

Figure 4

Examples of worksheet responses are as follows. Seven of the ten pupils, responding to a question about a pattern in the data, correctly identified the trends for height to increase with shoe size and for both to increase with age, from the numerical data alone. One pupil, who reported that height and shoe size increase with age, pointed out "but this isn't always like that". The children were also asked: "Are there any data points which don't seem to fit in very well?" The majority of pupils were unable to answer; subsequent discussion indicated that the notion of fitting points to a line was unfamiliar to them and they found this question difficult to comprehend; we concluded that it would make a good topic for a class discussion next time. Only four pupils answered the questions: "What additional data would be useful? Who could you get this extra data from?" Three sensibly stated that data could be obtained from younger, smaller people or middle school pupils. One of these added, "There would be no point getting more older people because they have stopped growing."

The activity proved successful when repeated with another group of 21 year 8 pupils, described as "bright and lively" by the teacher. More data and more correct responses were obtained from this group than the previous group. For example, 7 pupils answered the question about who they might obtain extra data from, although this time none stated that data could be obtained from younger or smaller people. Instead a diverse range of imaginative responses was obtained: one pair of pupils suggested using athletes to see "if their sport affects their body"; another pair suggested "family, friends and neighbours"; a further pair suggested weighing the subjects from whom data had been obtained: the final response thoughtfully stated, "It would be useful to shoe makers because the shoes have to be strong enough to distribute the height and to hold the height." Again, this question offers rich material for a more extended discussion with pupils.



The trials were considered very successful by the teacher, who was keen to use the activity again with other year 8 groups and to extend it to older groups as well. He felt that the pupils had not only acquired useful experience with using the Pocket Book spreadsheet and graphing facilities, but had gained some insight into the process of graphing two related variables. The responses to the open-ended questions support this view, although a substantial amount of data was missing and the degree of understanding of the remaining pupils is uncertain. Those who did respond were generally able to identify the trends of height increasing with shoe size and of both variables increasing with age. Some could detect anomalous data points and interpolate from their graphs. A few realised that additional data from subjects at the lower end of the age range would be useful.

Time was a major problem. The procedure required on the Pocket Book to obtain a graph of two variables plotted one against the other was complex, and individual pupils required considerable help from the teacher and the researcher. Some of the pupils, as novice Pocket Book users, found it difficult simply to follow the given list of unfamiliar commands. This meant that discussion time was severely limited and a significant proportion of pupils failed to complete their worksheet questions. More time would certainly have been needed if pupils were to collect the data themselves. Since some of the data came from their own body measurements, however, they appeared to relate to it successfully.

The research team and the teacher concluded that this investigative activity had a very positive outcome and a great deal of potential; it could usefully be extended to older age groups. We also realised that spreading the activity over 2 sessions in future would be more productive (although attempting to issue pupils with the same Pocket Book machines on two occasions could be problematic).

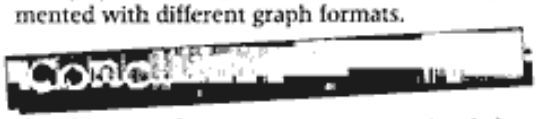
A few months later, an extended activity was undertaken with a year 10 group of 21 pupils. The children involved all had prior experience of using the Pocket Book and of spreadsheet activities on desktop computers. They were a very mixed ability group, with a concentration of low ability pupils. The trial took place over two consecutive 50-minute lessons, 2 days apart. This allowed time for extending the activity and answering the worksheet questions, and for children to collect their own data this time.

In the first lesson, each pupil's height in metres was measured by the teacher using a rule fixed to the wall. Shoe sizes were requested from each individual at the same time. Most pupils produced a coherent graph showing a visible linear trend by the end of the lesson. Pupils recorded their Pocket Book security numbers so that they could be issued with the same machines for the second lesson. This proved much more straightforward to organise than had been anticipated.

In the second lesson, the children were asked to complete their graphs if necessary and to work on the worksheet questions. An additional interpolation question was added to extend the graph to the top end of the height range, asking the shoe size of a person 2 metres tall. We attempted to overcome the Pocket Book limitation on graphing two variables – and to explore the unfamiliar notion of fitting points to a line – by asking pupils to draw a best fit line onto their sketch graphs on paper using a ruler. Thus, once all pupils had sketched their graphs, the teacher introduced the unfamiliar notion of lines of best fit; they appeared to grasp this notion quickly.

Another extension to the activity used hand span as well as shoe size. The pupils drew around their hands on paper and used a ruler to measure their hand spans (from thumb to little finger with hand fully spread) in centimetres. As with height, hand span measurements were announced verbally by individuals and recorded by the rest of the class. The pupils then entered the measurements into a fourth column of their spreadsheets and plotted a graph of hand size against height. They were asked to look for a trend in the new data; little was visible since there were several tall people who had small hand spans. As one child told me, "No, it was all bunched up and rubbish!"

Problems encountered during the year 8 trials were generally overcome by using the older age group and by having more time available. The children completed their worksheets more fully and required less help with using the Pocket Books. Most pupils went on to label their axes and graphs (with guidance) and some experimented with different graph formats.



The shoe size data set was more restricted than that in previous trials and produced a reasonably clear linear trend only when the y-axis scale contained sufficiently large intervals; fortunately the Pocket Book scaled the axes automatically in this way. The exercise of plotting hand size against height offered an interesting comparison for the pupils, since the relationship was not at all clear-cut. This trial was again considered very successful by the teacher, who felt that the activity was entirely suitable for year 10 groups as well as for younger pupils. The responses to the open-ended questions confirm that most pupils had gained some insight into the process of graphing two related variables. This time there was very little missing data and pupils were generally able to identify the trend of height increasing with shoe size. Some could detect anomalous data points and most could both interpolate and extrapolate from their graphs. In summary, despite its physical limitations, the Pocket Book proved a useful tool for provoking thinking about graphs and relationships between quantitative variables in pupils of lower secondary school age.

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Reference
Hennessy, S.: 1997, Portable technologies and graphing investigations: Review of the literature,
Computer-Assisted Learning Research Group technical report no. 175, Open University. (Submitted for publication, February 1998)

1. This machine was adapted from the Psion Organiser for the educational market; it contains a 256k RAM and a 512k ROM and comes with built-in menu-driven software including a word processor with spell check, a database, and a spreadsheet with related graphing facility and calculator functions. It measures only 8.5 x 16 x 2 cm.

Integrated Learning Systems

Trevor West

Technology is steadily moving on and it is no surprise that the 'programmed learning' systems of the 1960's and 70's have continued to be developed using the dramatically increased power of modern computers. The level of interest in using computing power to support learning is growing leading to the coining of the phrase 'integrated learning systems' (ILS). There are currently two major competitors in the field as far as mathematics is concerned, Global Maths and SuccessMaker.

NCET has undertaken some initial research into the effectiveness of these systems. Their conclusions regarding Global Maths are inconclusive but they report a positive effect with SuccessMaker. In Somerset there is growing interest in ILS with SuccessMaker the front runner. Buckler's Mead School and, more recently, Blake School have been using SuccessMaker, both on a networked basis. I understand that a few other Somerset schools have the software on single stand-alone systems.

SuccessMaker is based around a central framework with a series of 'modules' that support learning in specific areas. The main module for mathematics is 'Math Concepts and Skills', which is designed for use with the majority of pupils from pre-school to about age fourteen but there are currently six others available, designed for various age groups up to sixth form level. Some

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