Critical evaluation of internet resources for teaching trend and variability in bivariate data

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**Introduction**

A search on the Internet for resources for teaching statistics yields multiple sites with data sets, projects, worksheets, applets, and software. Often these are made available without information on how they might benefit learning. This paper addresses potential benefit from resources that target trend and variability relationships in bivariate data.

The paper is in five parts. The first is this introduction. In the second, trend and variability are defined. In the third, I quote research on the characteristics of data that influence students’ discernment of trend and variability, and identify data sets that have particular characteristics and that can be freely downloaded from the web. The fourth part of the paper is a short review of free text-based resources. The final part is a review of spreadsheet programs and Java applets. The paper is relevant to teaching and learning in secondary schools.

**Trend and variability**

Trend encompasses the notions of covariation between a succession of data points, the possibility of unrealised data between the extremes of available data (interpolation), and the possibility of unrealised data beyond the extrema (extrapolation) (Ainley, Pratt & Nardi, 2001). Variability is the way data vary (Reading & Shaughnessy, 2004) and in this paper I use the term to mean variability which is manifested as deviation from a trend.

Issues for teaching are that students need to learn to notice and acknowledge trend and variability and, as well, represent them and describe them, measure and model them (for prediction and other purposes), explain them, and develop investigative strategies in relation to them (Reading & Shaughnessy, 2004; Wild & Pfannkuch, 1999). The focus in traditional curricula has been on trend but current recommendations are that variability should receive as much, if not more, attention (Cobb, McClain &
Gravemeijer, 2003; Reading & Shaughnessy, 2004). Analysis cannot be considered to be statistical unless variability is recognised.

**Data sets**

**Contexts of data**
It is widely accepted that working with real data benefits learning, however, students' recognition of trend relationships can hinge on the students being familiar with the contexts of the data (Cobb et al., 2003). Familiarity can be encouraged through class discussion, but certain situations are likely to be familiar to all students, most notably situations involving change over time: students generally possess intuitive ideas about change in phenomena (such as temperature) over time and these ideas support interpretation (Leinhardt, Zaslavsky & Stein, 1990).

In addition, interpretation is simplified if the dependent variable is measured vertically (Leinhardt et al., 1990). Examples are the height of students and plant height. In these cases, the heights of points above the horizontal axis on a scatter plot resemble the physical heights being represented. So, literal interpretation of the graph (e.g., that height increases as age increases) will be consistent with common-sense reasoning.

By way of contrast, literal interpretation of a graph is sometimes at odds with reality (Leinhardt et al., 1990). An example is a plot of swimming records over time. Swimming records are measured in seconds, minutes etcetera and present the contradiction that improvement, which is a positive outcome, corresponds with a negative trend. Analysis of such data might best be delayed until students gain confidence in discerning and describing simpler trend relationships.

Explaining variability (i.e., deviation of data from a trend) calls for knowledge of uncontrolled variables (Wild & Pfannkuch, 1999). These include environmental variables that are operational in the situation from which data are derived, and measurement and recording variables. For example, if corn is grown from seed and height data are generated each day of the growing cycle, then the heights recorded on any day could differ because of (a) differences in growing conditions (soil quality, and the amount of water, sunlight, fertiliser that individual plants receive), (b) greater or lesser accuracy in measurement, and (c) recording errors. Nicholson (1997) found that the provision of multivariate data from which students extract and analyse bivariate data can help them realise that uncontrolled variables are always present and act in combination so that data generally exhibit variability (i.e., are not perfectly correlated).

In summary, key considerations in selecting data sets from the internet for instruction are students' likely familiarity with the contexts of data or whether familiarisation can reasonably be brought about by discussion. Data with time as the independent variable and/or height as the dependent variable could be used initially, followed by other data for which interpretation is less intuitive.
Geometric configuration of graphed data
Trend is easily discerned if data are such that there is one value of the dependent variable for each value of the independent variable and covariance between adjacent points is always positive or always negative (Ainley et al., 2001). Outliers and local irregularity, where covariance between adjacent points changes direction (see Figure 1), can distract students from perceiving a trend — rather they focus on variability (Ben-Zvi & Arcavi, 2001). See Figure 1 in which the Olympic records over time exhibit positive covariation except between 1912 and 1920, 1968 and 1972, 1976 and 1980, and 1988 and 1992. As well, if data are horizontal or nearly horizontal then students may deny there is a trend (Noss, Pozzi & Hoyles, 1999): trend is more accessible if the rise (or fall) in data is steep.

Figure 1. Olympic gold medal discus-throw 1896–1992 distances (Olympic Gold data, Exploring Data database, exploringdata.cqu.edu.au/datasets.htm).

Albeit, the appearance of data (rise and fall, distinctness of outliers, etc.) partly depends on the scales and dimensions of the graph, and manipulating these is feasible when technologies are used for the graphing. One option is to change the vertical scale. See Figure 2 with the scale chosen to emphasise trend, and Figure 3 with the same data and the scale chosen to emphasise variability. Otherwise, a graph can be reduced or enlarged by dragging its border, to respectively emphasise trend and variability. As well, when technologies are used for instructional purposes, outliers are easily removed, and consequently trend might be highlighted.

Bivariate data that form stacks (see Figure 4) have been found to invite discernment of variability and trend (Cobb et al., 2003; Forster, 2006). Stacks occur if data have a one-to-many correspondence, which arises if the independent variable is discrete (Figure 4) or can be brought about by rounding (see Figure 5 which shows the data from Figure 2 after weights were rounded to the nearest 5 kg). Successive rounding can reduce the number of stacks and result in slightly different regression models, and exploring this could highlight for students that rounding decisions affect analysis and the conclusions reached. Furthermore, stacks can be viewed as distributions of univariate data, and trend lines can be treated as lines through the central

![Figure 3](image1.png)

*Figure 3. The graph in Figure 2 rescaled to emphasise variability.*

![Figure 4](image2.png)


![Figure 5](image3.png)

*Figure 5. Height against weight (a continuous variable) with weights rounded to the nearest 5kg.*
(mean or median) values. Regression analysis was founded on these ideas (Stanton, 2001) and they were used to guide instruction in the studies reported by Cobb et al. (2003) and Forster (2006). In both studies, students devised credible methods for locating trend lines when asked to analyse stacked data.

In summary, the geometric configuration of data warrants attention because it can favour discernment of trend or variability, or can invite discernment of both. Data with a one-to-one \((x,y)\) correspondence and consistently positive or negative covariation would suit initial consideration of trend. Stacked data highlights vertical variability and trend relationships, and can support the definition of mathematical trend models.

Data sets with the various geometric configurations and a linear trend, or no trend, are listed in Table 1, together with their contexts and the internet databases from which they can be retrieved. The main criterion for selecting the sets was the contexts would probably be familiar to secondary school students. It is noted that most of the data files are in .xls format or can be imported into Excel by selecting the toolbar commands “Data” and “Import external data”. Data sets in contexts that would probably be familiar to secondary students and that exhibit non-linear trend patterns are listed in Table 2. Some sets lend themselves to testing multiple models (see column headed “trend”).

Anscome’s (1973) four sets of decontextualised data also deserve mention as being useful for teaching. They each comprise eleven points and produce the same regression line and correlation coefficient but display different trend patterns (linear, quadratic, etc.). The sets can be used to highlight that trend models must be checked visually. They are available on the Exploring Data (ED) database <exploringdata.cqu.edu.au/datasets.htm>.

Checking the viability of the intercepts in relation to the contexts of data is another important aspect of choosing trend models. The diamond ring data set (diamond.dat, see Table 2) can be used to highlight the need for this. The intercepts for the linear model are incongruous in relation to the context, whereas the intercepts for quadratic and exponential models are reasonable. In fact, checking fit visually and checking the intercepts are two domains where students fall down: they tend to choose linear models over others and are satisfied that a line is appropriate if the correlation coefficient for data is high (Chu, 1996; Lingefjärd, 2002).

Text resources

Text resources for teaching and learning trend and variability include descriptions of the contexts and collection procedures for data. For example, detailed information is available for data sets from the Journal of Statistics Education (JSE) archive <www.amstat.org/publications/jse/jse_data_archive.html>. Briefer descriptions are provided on the ED database <exploringdata.cqu.edu.au/datasets.htm>. Such information can be important for valid interpretation of data.
Table 1. Data sets for exploring trend and variability in bivariate data: linear trend or no trend.

<table>
<thead>
<tr>
<th>Data set</th>
<th>Source</th>
<th>Description</th>
<th>Variables</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olympic Gold</td>
<td>Olympic Gold</td>
<td>Olympic Games 1984-2000</td>
<td>Results by event</td>
<td>linear, 1-to-1</td>
</tr>
<tr>
<td>Olympic Games</td>
<td>bASD</td>
<td>Olympic track and field results 1984-2000</td>
<td>Olympic track and field results 1984-2000</td>
<td>linear, 1-to-1</td>
</tr>
<tr>
<td>Olympic Games</td>
<td>cBBC</td>
<td>Olympic track and field results 2004</td>
<td>Olympic track and field results 2004</td>
<td>linear, 1-to-1</td>
</tr>
<tr>
<td>Hat size</td>
<td>dJSE</td>
<td>Hat size, circumference of hats</td>
<td>Hat size, circumference of hats</td>
<td>stacked linear</td>
</tr>
<tr>
<td>Water resources</td>
<td>e QELP</td>
<td>Water resources</td>
<td>Water resources</td>
<td>stacked linear</td>
</tr>
<tr>
<td>Fruitfly data</td>
<td>f PC</td>
<td>Number of companions, height, weight</td>
<td>Fruitfly data</td>
<td>stacked linear</td>
</tr>
<tr>
<td>Cigarettes data</td>
<td>g Stanton (2001)</td>
<td>Tar content, nicotine content, smoke</td>
<td>Cigarettes data</td>
<td>scattered linear</td>
</tr>
</tbody>
</table>

References:
- f PC: Pomona College database <http://www.economics.pomona.edu/StatSite/eclectic.html>
- 1-to-1 is to be taken to mean that for each x value there is a single value of y as in Figure 1.
<table>
<thead>
<tr>
<th>Dataset</th>
<th>Source</th>
<th>Description</th>
<th>Variables</th>
<th>Structure</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forests</td>
<td>QELP</td>
<td>DataSet #056, tree ring widths over time</td>
<td>✓</td>
<td>1-to-1</td>
<td>exponential</td>
</tr>
<tr>
<td>Water resources</td>
<td>QELP</td>
<td>DataSet #071, discharge from flooded river over time</td>
<td>✓ - ✓</td>
<td>1-to-1</td>
<td>exponential</td>
</tr>
<tr>
<td>Oil production</td>
<td>ED</td>
<td>World’s oil production in barrels 1880-1988</td>
<td>✓ - ✓</td>
<td>1-to-1</td>
<td>exponential</td>
</tr>
<tr>
<td>Used car prices</td>
<td>Ound</td>
<td>Used car data (multiple variables)</td>
<td>✓ - ✓</td>
<td>stacked</td>
<td>exponential</td>
</tr>
<tr>
<td>diamond.dat</td>
<td>JSE</td>
<td>Carat weight of diamonds, price of diamond rings</td>
<td>✓</td>
<td>stacked</td>
<td>multiple</td>
</tr>
<tr>
<td>fat.dat</td>
<td>JSE</td>
<td>Body measurements</td>
<td>✓ - ✓</td>
<td>stacked</td>
<td>multiple</td>
</tr>
<tr>
<td>body.dat</td>
<td>JSE</td>
<td>Body measurements (multiple variables)</td>
<td>✓ - ✓</td>
<td>scattered</td>
<td>multiple</td>
</tr>
<tr>
<td>Gestation period</td>
<td>CPA</td>
<td>Gestation period, average longevity for 43 animals</td>
<td>- ✓</td>
<td>scattered</td>
<td>multiple</td>
</tr>
<tr>
<td>Global temp</td>
<td>ED</td>
<td>Global mean temperature 1866-1996.</td>
<td>✓ - ✓</td>
<td>scrambled</td>
<td>multiple</td>
</tr>
<tr>
<td>normtemp.dat</td>
<td>JSE</td>
<td>Temperature, gender and heart rate data (n=130)</td>
<td>✓</td>
<td>scattered</td>
<td>multiple</td>
</tr>
<tr>
<td>poverty.dat</td>
<td>JSE</td>
<td>Population and economic indicators for 97 countries</td>
<td>✓ - ✓</td>
<td>scattered</td>
<td>multiple</td>
</tr>
<tr>
<td>Climate</td>
<td>ABM</td>
<td>Daily, weekly, monthly temperature, rainfall etc</td>
<td>✓</td>
<td>1-to-1</td>
<td>sinusoidal</td>
</tr>
<tr>
<td>Astronomical</td>
<td>GAD</td>
<td>Sunrise/sunset, moonrise/moon set, planet rise and set</td>
<td>✓ - ✓</td>
<td>1-to-1</td>
<td>sinusoidal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>times in each Australian State</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

References:
- CPA: Contemporary Precalculus through Applications database <http://courses.ncssm.edu/math/CPTA/data/>
- 1-to-1 is to be taken to mean that for each x value there is a single value of y, as in Figure 1.
- PC: Pomona College database <http://www.economics.pomona.edu/StatSite/eclectic.html>
Other text resources include articles in online journals such as:
- Teaching Statistics <www.rsscse.org.uk/ts> and the

They provide a diverse range of ideas for teaching, together with reasons why particular approaches might benefit learning, and critique on the implementation of the approaches in actual classes. For example, Hunt (1994) presents a project where students collected their own data. The project called for sampling, measurement, formulation of a trend model, and explanation of variability in order to explain intercepts of the model. Sowey (2001) lists applications of statistics and statistical propositions that, in his experience, surprise students and motivate learning. Weldon (2005) discusses a variety of strategies for the graphical analysis of bivariate data. Rouncefield (1995), Hanley and Shapiro (1994), and Chu (1996, 2001) report on classroom use of data sets from the JSE data archive. Other articles are listed in Tables 1 and 2 next to the data sets to which they relate.

Other types of text resource include:
- suggestions for collaborative projects on the Maths Forum website <mathforum.org/workshops/sum96/data.collections/datalibrary>
- case studies (e.g., “Physical Strength” and “Job Performance”), Rice Virtual Lab in Statistics <www.ruf.rice.edu/~lane/rvls.html>

The case studies and examination solutions demonstrate that multiple approaches can be used for analysing any data set.

**Spreadsheets**

Spreadsheets have been found to benefit the teaching and learning of trend and variability in several ways. Firstly, scatter plots can be produced quickly on spreadsheets and the plots can be projected onto a whiteboard for the purpose of class discussion. Secondly, if students are using a spreadsheet for analysis, they can graph their data and focus on interpreting the graph, without the distraction of having to plot individual points.

Thirdly, interactive capabilities of spreadsheets can be used to highlight trend and/or variability relationships (Ainley et al., 2001; Ben-Zvi & Arcavi, 2001; Forster, 1997). Options include adding or deleting data from a table and observing changes in the graph; dragging the graph space in order to enlarge it, and changing the vertical scale on the graph so that data appear more or less dispersed (see Figures 3 and 4); calculating summary statistics and observing how they change when data change; superimposing estimated trend lines on the scatter plot using a line-drawing tool; and superimposing least squares regression models on the scatter plot. Commercial spreadsheets such as Excel offer all these capabilities. Free spreadsheet programs on the web usually offer some of them. Two examples are:
- the Winstats Peanut Software program, Parris (2005) <math.exeter.edu/rparris>
Customised spreadsheets and Java applets

Customised spreadsheets and Java applets that target particular aspects of trend and variability are also available for free downloading. Topics include the least squares regression principle, correlation, and random variation in samples. A search on each topic produced the following.

Least squares regression principle

Items on the least squares regression principle include the:

  <matti.usu.edu/nlvm/nav/category_g_4_t_5.html>
- National Council of Teachers’ (NCTM, 2000) Least squares regression applet <standards.nctm.org/document/eexamples/chap7/7.4>
- West’s (n.d.) Regression applet  
  <www.stat.sc.edu/~west/javahtml/Regression.html>
- Finzer’s (1995) Least squares applet  
- Proquest Information and Learning Company’s (2005) Least squares activities A and B  
  <www.explorelearning.com/index.cfm?method=cResource.dspResourcesForCourse&CourseID=266>
- Hunt, Tyrrell, and Nicholson’s (2001) spreadsheet, What is least squares?  
  <www.mis.coventry.ac.uk/~nhunt/regress/listof.htm>

The properties of these applications are summarised in Table 3. In particular, the Matti and NCTM applets have been found valuable for teaching (Forster, 2006): use of the Matti applet can stimulate students in thinking about how to calculate a regression line and the NCTM applet illustrates the least squares relationship numerically and graphically. The applet by West could also support conjecture on calculating regression lines and Finzer’s applet illustrates the least squares relationship, but both have fewer interactive capabilities and lack detail that is available on the Matti and NCTM applets (see Table 3). The Proquest applets offer a range of options for manipulating data and accessing summary statistics (see Table 3), but free use is limited to 5 minutes. The spreadsheet by Hunt et al. lacks the dynamic affordances of Java applets (e.g., ability to drag points on the graph) but includes an interactive worksheet that guides the user in locating regression lines through data that the user enters.

Table 4 summarises other applets and customised spreadsheets that address the development of skills to do with fitting trend models and predicting from them, and still others that target understanding to do with trend models. Potentially, the applications could benefit teaching and learning, but reports on realised benefit from them do not seem to be available.
### Table 3. Java applets and customised spreadsheets on the least squares regression principle.

<table>
<thead>
<tr>
<th>Properties and interactive capabilities</th>
<th>Matti</th>
<th>NCTM</th>
<th>West</th>
<th>Finzer</th>
<th>Proqu.</th>
<th>Hunt</th>
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<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Graph and table</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Co-ordinate system</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>-change scales</td>
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<td>-</td>
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<td>-</td>
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</tr>
<tr>
<td>Data</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-add points to a graph by clicking</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>-drag points on a graph</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-enter data in a table</td>
<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Estimate trend-line on scatter plot</td>
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<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-drag existing line</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-enter m and c values, line appears</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-select m and c with sliders, line appears</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Graphics on scatter plot</td>
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<td>-</td>
<td>✓</td>
<td>✓</td>
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<td>-regression line</td>
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<td>-</td>
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</tr>
<tr>
<td>-mean point on regression line</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-residuals to estimated trend line</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>-squares on the residuals to estimated trend line</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-shortest distances to estimated trend line</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Summary values near plot</td>
<td></td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-equation of estimated trend line</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-equation of regression line</td>
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<td>-</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>-mean point</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-correlation coefficient</td>
<td>✓</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-predictions from trend model</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-residuals</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-squares on individual residuals</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-sum of the squares-on-the-residuals</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Applet/spreadsheet title | Author / website | Topic

**Skill development**
- Regression by eye
  - "Rice Virtual Lab in Statistics"[^a]  
- Trendlines in Excel
  - "Hunt et al. (2001)"[^b]
- Solving using trend lines
  - "Proquest Information and Learning Company (2005)"[^c]

**Understanding**
- Polynomial regression
  - "Vestac Java applets"[^d]
- Investigate transformations
  - "Hunt et al. (2001)"[^b]
- Experiment with other criteria
  - "Hunt et al. (2001)"[^b]
- Linear regression
  - "Stanton (n.d.)"[^e]
- Residual plots
  - "Hunt et al. (2001)"[^b]

[^a]: Rice Virtual Lab in Statistics [http://www.ruf.rice.edu/~lane/stat_sim/index.html]
[^b]: Hunt et al. (2001) [http://www.mis.coventry.ac.uk/~nhunt/regress/listof.htm]
[^e]: Stanton (n.d.) [http://www.math.csusb.edu/faculty/stanton/probstat/index.html]
Correlation

The applets/spreadsheets on correlation focus on the relationship between the distribution of data on the scatterplot and values for Pearson’s correlation coefficient r. They include:

- Correlation revisited (Neuwirth, 1996)  
  <sunsite.univie.ac.at/Spreadsite/statexamp/>

- Correlation (Proquest Information and Learning Company, 2005)  
  <www.explorelearning.com/index.cfm?method=cResource.dspResourcesForCourse&CourseID=266>

- Components of rand regression by eye (Rice Virtual Lab in Statistics)  
  <www.ruf.rice.edu/~lane/stat_sim/>

- Guessing correlations and Investigating correlation (Hunt et al., 2001)  
  <www.mis.coventry.ac.uk/~nhunt/regress/listof.htm>

“Correlation revisited” and “Correlation” allow the user to change r with a slider and observe the effect on a scatter plot of given data. The “Correlation” applet graphs the regression line as well as the data, and the naïve user could be misled into thinking r depended solely on the slope of the regression line.

“Components of r” allows the user to explore relationships between r, the spread in X, spread in Y, slope of the regression line, and explained and unexplained variation. This applet supports identification of more properties of r than do “Correlation revisited” and “Correlation”. “Regression by eye”, “Guessing correlation”, and “Investigating correlation” allow the user to guess r values for given data or data that they enter, then, check the guesses.

Random variation

Applets and spreadsheets on random variation in samples from the same population are listed in Table 5. They illustrate variation between scatterplots for samples, and variation between regression lines, parameters of regression lines, and residuals (see Table 5). Furthermore, while variation between samples may not be treated formally in school statistics courses, demonstration with the applets could highlight for students that deterministic conclusions based on single samples, especially small ones, are inappropriate: rather they might appreciate that trend for a sample is an estimate of underlying trend (Nicholson, 1996).

Concluding comments

In this paper I have suggested data sets for introducing students to trend and variability relationships. The criteria that I used in choosing them were (a) they were derived from contexts that might be familiar to secondary-school students, and (b) they exhibit different geometric structures when graphed. The Australian Bureau of Statistics CensusAtSchool database <www.abs.gov.au> is another source of data in contexts that are familiar to students. Schools can register to contribute and retrieve data.

I have also identified Java applets and spreadsheets for possible use in teaching. Other examples are available on the websites that were referenced.
in the paper, but the applications that I chose indicate the scope of what is available. It also needs to be acknowledged that the applets and spreadsheets target technical understanding of trend and variability (the least squares principle, etc.) and technical understanding is insufficient for meaningful analysis of data. Amongst other things, students need to learn strategies to reveal trend and variability in bivariate data and, as well, learn to interpret regression models and variability in relation to the contexts of data.

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References


<table>
<thead>
<tr>
<th>Applet/spreadsheet title</th>
<th>Author/website</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression plot</td>
<td>aVestac</td>
<td>Select parameters for regression line for population, sample size. View scatterplots and regression lines for multiple samples.</td>
</tr>
<tr>
<td>Histograms of slope and intercept</td>
<td>aVestac</td>
<td>Same as above but view histograms for slope and y intercepts for trend lines for samples.</td>
</tr>
<tr>
<td>Exploring variation in predictions</td>
<td>bHunt</td>
<td>Choose sample size. View scatter plot and regression line for population (n=50), and data and regression lines for samples superimposed on the plot.</td>
</tr>
<tr>
<td>Sampling distribution of r</td>
<td>bHunt</td>
<td>Choose population correlation coefficient _ and sample size. View scatter plots and histogram of r for samples.</td>
</tr>
<tr>
<td>Normal probability plots</td>
<td>bHunt</td>
<td>Choose sample size and distribution of errors for population. View distribution of residuals for samples.</td>
</tr>
</tbody>
</table>

Table 5. Applets and spreadsheets on random variation in samples from the same population.

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a Vestac Java applets <http://www.kuleuven.ac.be/ucs/java/index.htm>
b Hunt et al. (2001) <http://www.mis.coventry.ac.uk/~nhunt/regress/listof.htm>


