Aim

To identify a range of factors which affect how devastating an earthquake event is to an area.

Hypothesis

There will a significant relationship between magnitude and number of fatalities: the greater the magnitude of the earthquake, the greater the impact in terms of number of fatalities.

Null hypothesis

There will be no significant relationship between earthquake magnitude and number of fatalities.

Method

Use the earthquake data on the right to carry out the tasks below.

1. Plot the location of the largest and deadliest earthquakes (1990–2011) on an outline map of the world.

2. Create a scattergraph to show the relationship between magnitude and the number of fatalities.

3. Ensure that the scattergraph has:
    - independent and dependent variables
    - a suitable scale
    - appropriate units
    - anomalies identified
    - a line of best fit
    - a title.

4. Analyse the scattergraph:
   What does the scattergraph suggest about the relationship between magnitude and number of fatalities? Make reference to the strength and direction of the relationship and acknowledge any anomalies in your answer.

Year	Magnitude	Fatalities	Location
2011	9	20896	Honshu, Japan
2010	8.8	507	Maule, Chile
2010	7	316000	Haiti
2009	8.1	192	Samoa Islands
2009	7.5	1117	Southern Sumatra, Indonesia
2008	7.9	87587	Eastern Sichuan, China
2007	8.5	25	Southern Sumatra, Indonesia
2007	8	514	Coast of Central Peru
2006	8.3	0	Kuril Islands
2006	6.3	5749	Java, Indonesia
2005	8.6	1313	Northern Sumatra, Indonesia
2005	7.6	80361	Pakistan
2004	9.1	227898	Northern Sumatra, Indonesia
2003	8.3	0	Hokkaido, Japan
2003	6.6	31000	Southeastern Iran
2002	7.9	0	Central Alaska
2002	6.1	1000	Hindu Kush Region, Afghanistan
2001	8.4	138	Near coast of Peru
2001	7.7	20023	India
2000	8	2	New Ireland Region, Papua New Guinea
2000	7.9	103	Southern Sumatra, Indonesia

5. Complete a Spearman rank analysis on the data.

$$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

6. Analyse the Spearman's rank correlation coefficient:
   What does the Spearman's rank analysis suggest about the relationship between magnitude and number of fatalities?

7. Write a conclusion.

8. Return to the original hypothesis. Do you accept or reject the hypothesis in light of your findings?

Other factors

What other factors may influence how hazardous an earthquake is?

1. Make a list of other factors which may influence the impact an earthquake has on an area other than magnitude. Discuss these with a neighbour.

2. Classify your thoughts on 'other factors' into either human or physical influences.

3. Classify any additional factors from the 'Impact factors' sheet into either human or physical influences.

Impact factors

Use the list below to classify any additional factors into human or physical influences.

Magnitude of the event	Depth of the focus
Distance from the epicentre	Population density
Urban/rural	Local ground conditions
Time of day	Frequency
Day of the week	Degree of earthquake proof design
MEDC/LEDC	Preparedness of the community
Type of process	Proximity to the coast

Teaching notes

This enquiry helps students appreciate the wide range of factors which may affect the impact of an earthquake on an area.

The data has been derived from 'Largest and Deadliest Earthquakes by Year 1990–2011' on the http://earthquake.usgs.gov/earthquakes/eqarchives/year/byyear.php website. The United States Geological Survey is an excellent source of earthquake data and information: http://earthquake.usgs.gov/earthquakes/recenteqsww/ provides a constantly updating map of the latest earthquakes in the world over the past seven days. In addition earthquake locations for the past seven days, automatically refreshing every five minutes, can be displayed in Google Earth by downloading a simple kml feed available at http://earthquake.usgs.gov/earthquakes/catalogs/.

The accompanying earthquake map has been produced from a blank world map available from http://english.freemap.jp/. The map locates the 21 earthquakes used as the data source and provides a hyperlink to the relevant United States Geological Survey webpages.

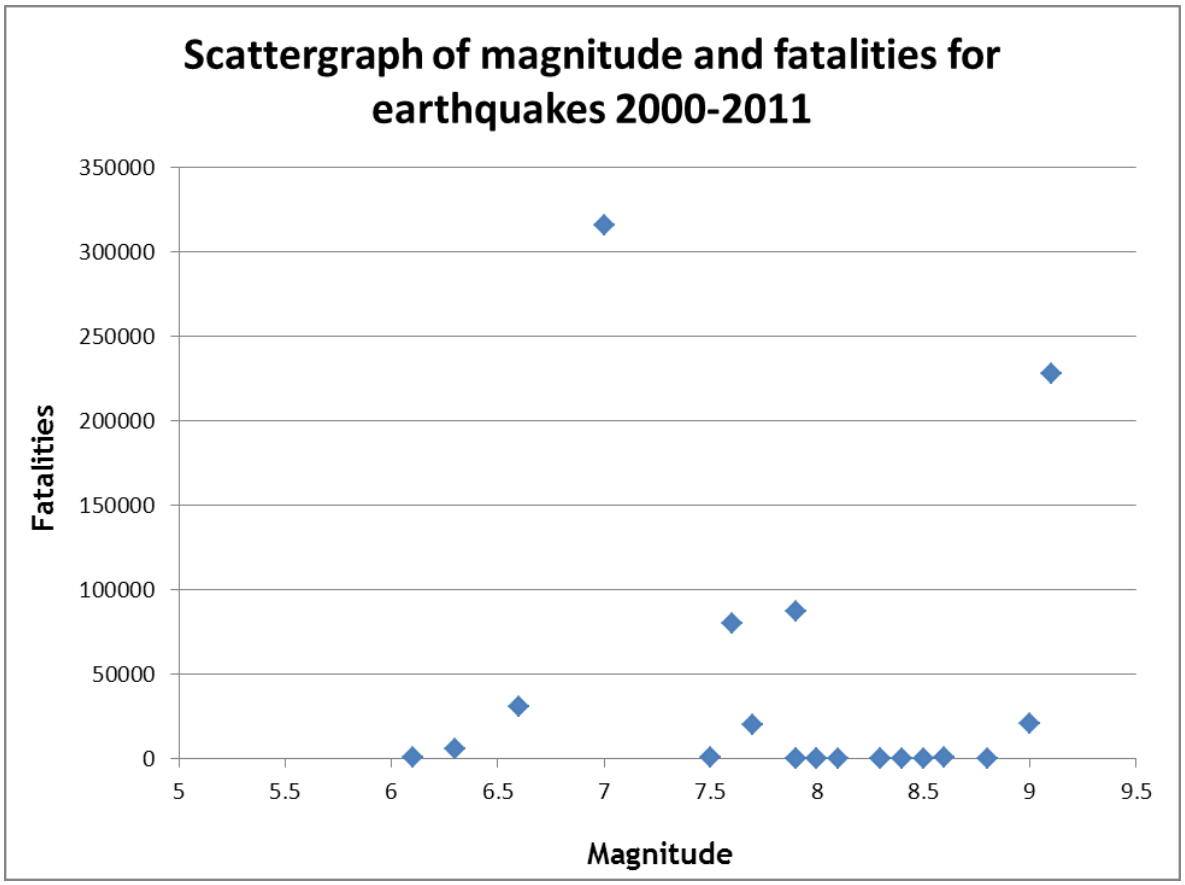
The lesson also works well if individual students or pairs of students have access to a PC. A spreadsheet program may then be used to graph the data.

It assumes that students are already proficient in using scattergraphs and Spearman's rank. If not, these skills could be built into the activity or used as a recap/reminder.

Students studying GCE Mathematics or Further Mathematics may also be familiar with the Pearson product moment correlation coefficient as a more accurate analysis than Spearman's rank. This can be obtained directly in Microsoft Excel using the =Pearson(range1,range 2) function. The Pearson coefficients are given under the Spearman's rank calculations for comparison. These are, however, identical if rounded to two decimal places.

Students will need:

- a copy of the enquiry (probably best issued page by page as required)
- an outline map of the world
- a sheet of graph paper
- a calculator and paper for Spearman rank workings
- paper for the 'Factors affecting the impact of an earthquake' exercise
- a set of impact factors.


Scattergraph of magnitude and fatalities for earthquakes 2000-2011
Fatalities
350000
300000
250000
200000
150000
100000
50000
0
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
Magnitude

Spearman's rank calculations

Year	Region	Magnitude	Rank	Fatalities	Rank	d	d^2
2011	Honshu, Japan	9	2	20896	6	-4	16
2010	Maule, Chile	8.8	3	507	13	-10	100
2010	Haiti	7	18	316000	1	17	289
2009	Samoa Islands	8.1	9	192	14	-5	25
2009	Southern Sumatra, Indonesia	7.5	17	1117	10	7	49
2008	Eastern Sichuan, China	7.9	13	87587	3	10	100
2007	Southern Sumatra, Indonesia	8.5	5	25	17	-12	144
2007	Coast of Central Peru	8	10.5	514	12	-1.5	2.25
2006	Kuril Islands	8.3	7.5	0	20	-12.5	156.25
2006	Java, Indonesia	6.3	20	5749	8	12	144
2005	Northern Sumatra, Indonesia	8.6	4	1313	9	-5	25
2005	Pakistan	7.6	16	80361	4	12	144
2004	Northern Sumatra, Indonesia	9.1	1	227898	2	-1	1
2003	Hokkaido, Japan	8.3	7.5	0	20	-12.5	156.25
2003	Southeastern Iran	6.6	19	31000	5	14	196
2002	Central Alaska	7.9	13	0	20	-7	49
2002	Hindu Kush Region, Afghanistan	6.1	21	1000	11	10	100
2001	Near coast of Peru	8.4	6	138	15	-9	81
2001	India	7.7	15	20023	7	8	64
2000	New Ireland Region, P.N.G.	8	10.5	2	18	-7.5	56.25
2000	Southern Sumatra, Indonesia	7.9	13	103	16	-3	9

$\Sigma d^2 = 1907$ $6\Sigma d^2 = 6 \times 1907 = 11442$

$n = 21$ $n^2 = 21 \times 21 = 441$

$n^2 - 1 = 440$ $n(n^2 - 1) = 21 \times 440 = 9240$

$6\Sigma d^2 \div n(n^2 - 1) = 1.2383$

Spearman's rank correlation coefficient = -0.2383 = -0.24 (to 2 dp)

Pearson product correlation coefficient (from Excel) = -0.2423 = 0.24 (to 2 dp)

Spearman's rank calculations (with Haiti 2010 anomaly removed)

Year	Region	Magnitude	Rank	Fatalities	Rank	d	d^2
2011	Honshu, Japan	9	2	20896	5	-3	9
2010	Maule, Chile	8.8	3	507	12	-9	81
2009	Samoa Islands	8.1	9	192	13	-4	16
2009	Southern Sumatra, Indonesia	7.5	17	1117	9	8	64
2008	Eastern Sichuan, China	7.9	13	87587	2	11	121
2007	Southern Sumatra, Indonesia	8.5	5	25	16	-11	121
2007	Coast of Central Peru	8	10.5	514	11	-0.5	0.25
2006	Kuril Islands	8.3	7.5	0	19	-11.5	132.25
2006	Java, Indonesia	6.3	19	5749	7	12	144
2005	Northern Sumatra, Indonesia	8.6	4	1313	8	-4	16
2005	Pakistan	7.6	16	80361	3	13	169
2004	Northern Sumatra, Indonesia	9.1	1	227898	1	0	0
2003	Hokkaido, Japan	8.3	7.5	0	19	-11.5	132.25
2003	Southeastern Iran	6.6	18	31000	4	14	196
2002	Central Alaska	7.9	13	0	19	-6	36
2002	Hindu Kush Region, Afghanistan	6.1	20	1000	10	10	100
2001	Near coast of Peru	8.4	6	138	14	-8	64
2001	India	7.7	15	20023	6	9	81
2000	New Ireland Region, P.N.G.	8	10.5	2	17	-6.5	42.25
2000	Southern Sumatra, Indonesia	7.9	13	103	15	-2	4

$\Sigma d^2 = 1529$ $6\Sigma d^2 = 6 \times 1529 = 9174$

$n = 20$ $n^2 = 20 \times 20 = 400$

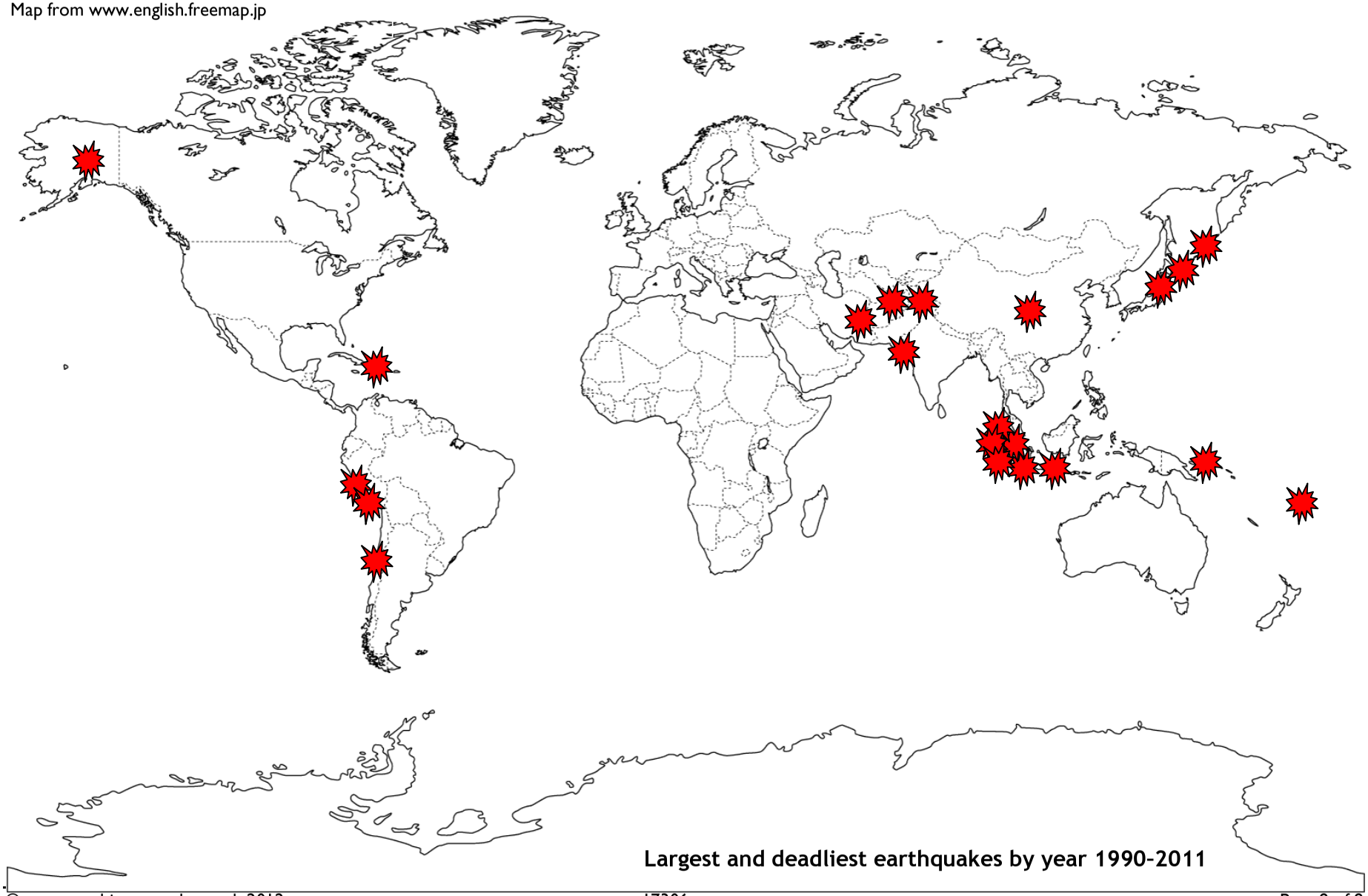
$n^2 - 1 = 399$ $n(n^2 - 1) = 20 \times 399 = 7980$

$6\Sigma d^2 \div n(n^2 - 1) = 1.1496$

Spearman's rank = -0.1496 = 0.15 (to 2 dp)

Pearson product correlation coefficient (from Excel) = - -0.1540 = 0.15 (to 2 dp)

Map from www.english.freemap.jp



Largest and deadliest earthquakes by year 1990-2011