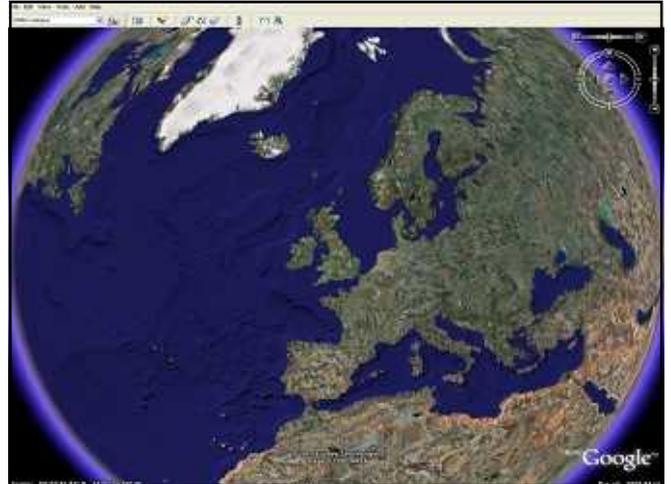
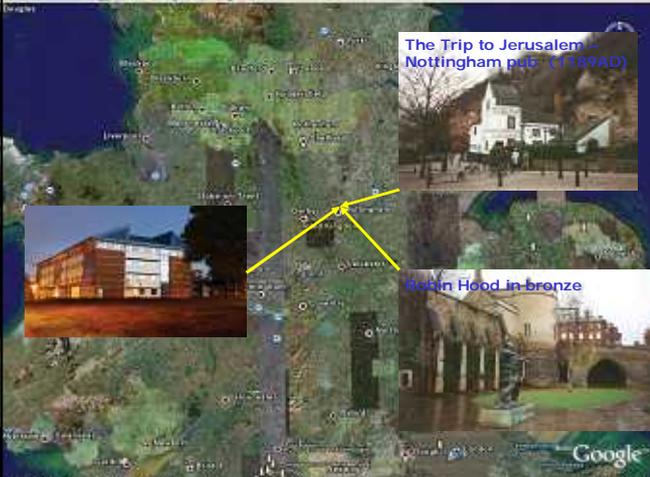


 **Developments in Teaching, Learning and Assessing through Statistical Problem Solving**

Centre for Statistical Education

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The Trip to Jerusalem - Nottingham pub (1189AD)

Robin Hood in bronze

Home of the RSSCSE



Home of the Royal Statistical Society
 Centre for Statistical Education
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 Neville Davies (Director)
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 Dan Rhodes (Web/technical developer)
 Mark Crowley (Teaching Fellow)
 Alison Davies (Administrator)



Summary

- I. Review of statistics & handling data (S&HD)
- II. Outcomes: re-thinking teaching statistics
- III. Outcomes: using a problem solving approach (PSA)
- IV. The assessment problem and its development
- V. Assessment marking
- VI. Results

I Review of Statistics and Handling Data



Adrian Smith's Post-14 Maths Inquiry

recommendation 4.4:

"(I) ...restore more time to the mathematics curriculum ...and (II) [recognise] the key importance of Statistics and Data Handling as a topic in its own right and the desirability of its integration with other subject areas."



QCA decided to review the S&HD content of GCSE maths.

To determine:

- what should remain core
- what may be beneficially seeded through other subjects



RSSCSE commissioned to complete the research

II Outcomes: re-thinking teaching statistics

First stage of national survey (Apr – Dec '05)

20% sample of schools surveyed

Key recommendations...

Teach statistics through **real world examples** *within* the mathematics curriculum.

Trial new ways of assessing the statistics and handling data coursework

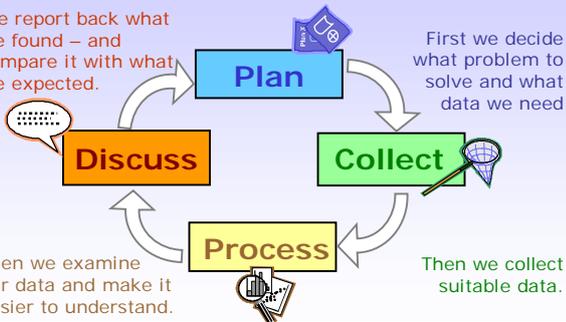
Develop a freely available comprehensive range of teaching materials using *real data*

The materials should teach through a *statistical problem solving approach (PSA)*.

III Outcomes: using a Problem Solving Approach

Problem solving approach

We report back what we found – and compare it with what we expected.



What skills are required to carry out the statistical enquiry cycle to solve problems?

- Courses in statistics concentrate on **Process**
- This involves techniques of statistics, models and much mathematics and is very important, but
- ...doing the other parts of the enquiry cycle requires a wide range of cognitive skills...
- In our survey of mathematics teachers in the UK, they clearly had the knowledge of techniques, but they were not *confident* in teaching the problem solving cycle, so...

Change the way we teach statistics...

- It is no good simply teaching students how to process and represent data (techniques), and then expect them to suddenly have the skills and knowledge for planning, collecting and discussing

Second stage of national survey (Jan – Dec '06)

Materials developed and trialled for teaching through the PSA
Assessment developed
Final report written

Key recommendations...The QCA should...

Promote the use of the PSA in *teaching and learning* statistics in schools through:

Developing Continuing Professional Development

Producing a range of materials based on real data and the Problem Solving Approach

Developing further the assessment from this project

Example resource for teaching through problem solving

QCA - RSS Centre Review of Handling Data and Statistics in GCSE Mathematics

How safe is your area?

This task uses a Problem Solving Approach and is designed to take approximately 3 hours of teaching time.

The resource enables teachers to help pupils consider the problem of safety of an area for living in. It involves the use of primary and secondary data.

For Teachers

Please start this by looking at the online resource which contains lesson plans and other materials.

Lesson Materials

Please select a version:

- Lesson Plan (Word)
- Lesson Plan (PDF)

Data sheets

Please select a region:

Then select data required:

Then select type of file:

Download the file

Click on databases

How safe is your area?

Plan Collect Process Discuss

How safe is the area you live in?

Setting the Scene

Plan Collect Process Discuss

How safe is the area you live in?

TV, radio and newspapers regularly report crimes and crime statistics.

Collecting Data

Plan Collect Process Discuss

How safe is the area you live in?

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Please select a region:

Then select data required:

Then select type of file:

Download the file

Click on databases

How safe is the area you live in?

Plan Collect Process Discuss

Click on a region to see which counties are grouped together for crime statistics

[Back](#)

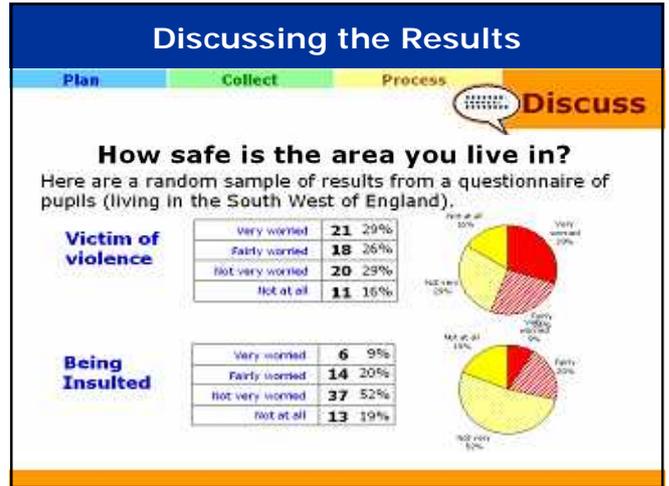
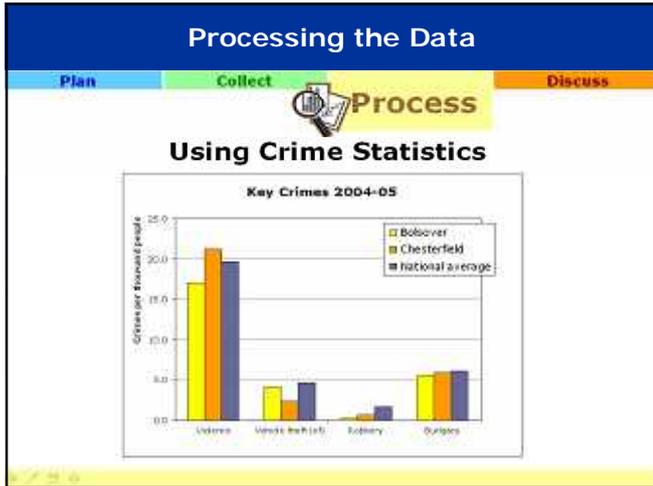
Data Downloaded from Website

How safe is your area? **Plan Collect Process Discuss**

East Midlands Crime Statistics

2005-06

	Population	Violence	Sexual	Robbery	Burglary	Theft of a vehicle	Theft from a vehicle
Derbyshire	939,328	14,796	1,167	922	9,123	3,693	2,179
Amber Valley	118,193	1,764	136	30	409	308	730
Nottingham	73,252	1,122	75	23	257	236	469
Cheneston	99,737	7,771	138	65	808	297	398
Dorset	232,741	8,305	394	495	1,408	828	2,352
Derbyshire Dales	69,063	695	41	4	126	103	420
Erewash	108,478	1,678	131	82	486	404	1,168
High Peak	90,654	1,426	81	28	259	167	491
North East Derbyshire	97,432	972	61	23	341	201	524
South Derbyshire	88,486	871	60	29	282	287	814
Leicestershire	980,498	21,286	1,381	1,044	5,167	2,566	2,413
Blaby	91,881	882	74	42	300	196	888
Charnwood	157,477	3,044	174	145	957	404	1,157
Harborough	79,057	750	49	13	260	141	342
Hambleton and Beauchamp	102,231	1,691	107	42	489	243	681
Leicestershire	265,097	11,156	729	625	2,284	1,032	2,093
Melton	48,232	860	40	5	158	130	365
North West Leicestershire	88,271	1,524	107	31	388	239	721
Rathfriland & Wigston	56,107	932	60	27	182	74	222



IV The assessment problem

'Assess the effectiveness of the materials produced for teaching through problem solving'

Two key issues:

- Formative assessment
- Summative assessment

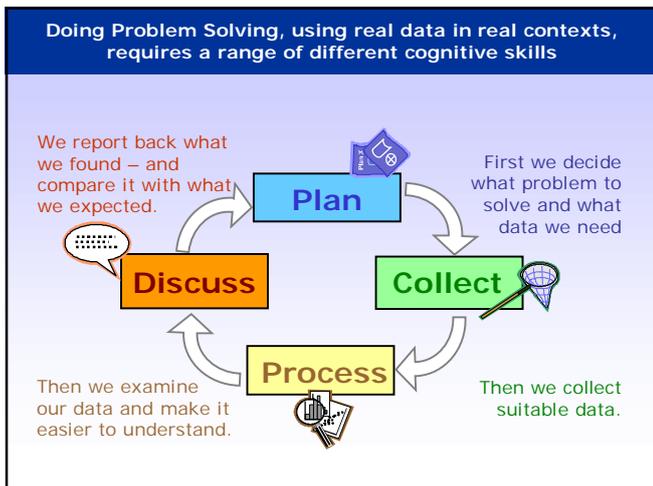
Formerly (in the UK) a coursework task was used to assess Problem Solving

Our approach to developing the assessment

In 2001 Anderson and Krathwohl revised Blooms' Taxonomy of Learning:

- Remembering
- Understanding
- Applying
- Analysing
- Evaluating
- Creating

- We thought that there would be a natural progression through these as the PSA evolves



New ideas needed

- To devise an assessment regime we need to identify the cognitive skills that are used in the statistical enquiry (problem solving) cycle
- What parts of the taxonomy are used at each stage?

Our approach to developing the assessment

- Mapping the PSA onto the revised taxonomy revealed that *each* stage (of the statistical enquiry cycle) uses at least *four* levels of the Taxonomy
- The PSA clearly provides an 'active learning tool' (Tanner, 2007, JRSS Series A)
- View of one university MATHS lecturer in UK – "My experience with teachers suggests that they all ignore the 'handling data cycle' - which seems to be a very recent English invention, which is blatantly contradicted by the way coursework is now structured."

Anderson – Krathwohl Taxonomy of Learning

		Cognitive dimension					
		Remember	Understand	Apply	Analyze	Evaluate	Create
Knowledge	Factual						
	Conceptual						
	Procedural						
	Meta-cognitive						

The Revised Taxonomy and the PSA

Example: Analyse and Procedural knowledge

- **To prepare** a plan for organising and recording the data
- **To determine** appropriate source(s) for the data
- **To be able** to design data collection sheets appropriate to the variable type
- **To be able** to organise data into appropriate tables/summary

Mapping Problem Solving to revised taxonomy

- Specify the Problem and Plan requires you to
 - Remember; understand; apply, analyse; create
- Collect data requires you to
 - Remember; understand; apply, analyse; create
- Process (and represent) requires you to
 - Remember; understand; apply, analyse.
- Interpret and discuss requires you to
 - Remember; understand; apply, analyse; evaluate; create
- All stages require a wide variety of cognitive skills

Decisions about the assessment

- Tanner (2007) paper on role play caused us to build in role play to the assessment regime
- Assessment time to be constrained
- Core problem(s) should have a familiar context to stimulate interest
- Online
- Accessibility was important

Example assessment

QCA-RSS Centre Project: Online Assessment



Getting the best deal
Online assessment

Please login using the code given to you by your teacher:

Getting the Best deal (for a mobile phone) -The assessment context

- The overall scenario concerns the purchase of a mobile phone
 - Three sections of assessment, A, B and C
- Section A
 - Holistic understanding
- Section B
 - Critique of imaginary students approach
- Section C
 - Role play as an advisor of what to purchase

Section A (Holistic) – drag and drop

QCA-RSS Centre Project: Online Assessment
Version 1.2

Getting the best deal

Tasks

The Problem Solving Cycle below has missing labels and descriptions for its four stages. Below are four descriptions of these stages. Drag and drop each description below onto the appropriate part of the cycle.

- Collect suitable data.
- Report back findings – compare it to what was expected.
- Decide what problem to solve and what data is needed.
- Examine the information and make it easier to understand.

Section A Section B Section C Time: 00:00:40 Screen 7 [Back](#)

Section B (critique) a student's approach to solving the problem

- The students to be assessed are presented with a context, a student has used the PSA to try to investigate what mobile phone contract would give her the best value for money.
- The candidates are presented with ten statements that comprise the write up of the investigation
- The questions of this section refer to these statements

Section B (critique) – the context

QCA-RSS Centre Project: Online Assessment
Version 1.2

Getting the best deal

Information

Ayesha is in y11. Her parents have paid for her mobile for four years, but now she has to pay for it herself.

She wants to get the best value for money. She remembers that her maths teacher taught her about the **problem solving approach** and how she could use it to solve any problem.

She decides to write up her investigations for her GCSE coursework.

Section A **Section B** Section C Time: 00:01:00 Screen 10 [Next](#)

Section B (critique)– drag and drop

QCA-RSS Centre Project: Online Assessment
Version 1.2

Getting the best deal

Tasks

Drag and drop each of the statements below, into the correct boxes opposite.

- Statement 1
- Statement 2
- Statement 3
- Statement 4
- Statement 5
- Statement 6
- Statement 7
- Statement 8
- Statement 9
- Statement 10

Section A **Section B** Section C Time: 00:01:19 Screen 11

Section B (critique)

QCA-RSS Centre Project: Online Assessment
Version 1.2

Getting the best deal

Tasks

Drag and drop each of the statements below, into the correct boxes opposite.

- Questions relate to different sections of the PSA
- Focus on what the student *did* (evaluate)
- Answers include comments, opinions and calculations

Statement 1

Statement 2

Statement 3

Statement 4

Statement 5

Statement 6

Statement 7

Statement 8

Statement 9

Statement 10

Section A **Section B** Section C Time: 00:01:19

Section B (critique) – Process

QCA-RSS Centre Project: Online Assessment
Section B

Getting the best deal

Tasks

Process statements

Using the data I collected I estimated my monthly use:
7 texts a day means I send $7 \times 30 = 210$ texts per month.
27 minutes of calls a day means I use $27 \times 30 = 810$ mins a month.

Using the plan the lady suggested, after 150 free minutes and texts, I would send 60 texts and use 650 minutes. The total cost is £55

B8. Why did Ayesha use the number 30 in the calculations 7×30 and 27×30 ?

Type in your answer here.

Time: 00:02:13

Section B (critique) – Discuss

QCA-RSS Centre Project: Online Assessment
Section B

Getting the best deal

Tasks

Discuss statements

Although the lady said it would be best, it looks like I would spend more if I had the deal.
£56 is a lot of money, I wonder if I have worked this out right.

B11. Would you advise Ayesha to change to the deal given that the calculations are correct?

Yes No Don't know

Why?

Type in your answer here.

Time: 00:02:26

Section C (role play) – the context

- New fictitious student
- Candidate advises

QCA-RSS Centre Project: Online Assessment
Section C

Getting the best deal

Information

Andy is in year 11 and is also trying to save money on his phone.

Unlike Ayesha, he started by looking at what deals were available and will then choose which one suits him.

Section C contains questions which ask you to help him do this.

Section C (role play) – Process

QCA-RSS Centre Project: Online Assessment
Section C

Tasks

Process

He decides to change the seconds to minutes and round them to the nearest half minute.

C9. Andy has done the first few, can you do the rest shown below?

Day	Day of week	Duration (seconds)	Duration (min)
14	W	193	3
15	Th	33	0.5
16	F	14	0
17	Sa	528	
18	Su	1766	
19	M	10	
20	Tu	20	

Time: 00:04:01

Section C (role play) – Discuss

QCA-RSS Centre Project: Online Assessment
Section C

Tasks

Discuss

Andy chose to look at a month of data. He chose the month at random. His teacher looks at his data and sees something interesting. The line graph below shows the number of texts and calls on each day of the month.

C19. Can you give a possible explanation for what happened here?

Type in your answer here.

Time: 00:07:49

Section C (role play) – return to Plan

QCA-RSS Centre Project: Online Assessment
Section C

Tasks

Plan

C20. Write a plan for an investigation to look at whether it is true that the more texts a person send, the fewer phone calls they make.

Type in your answer here.

This is the last question. Only click 'Next' when you have finished.

Time: 00:08:07

What happened

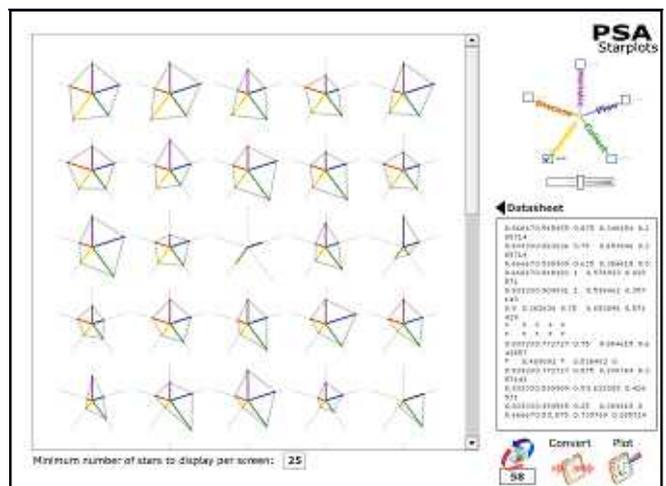
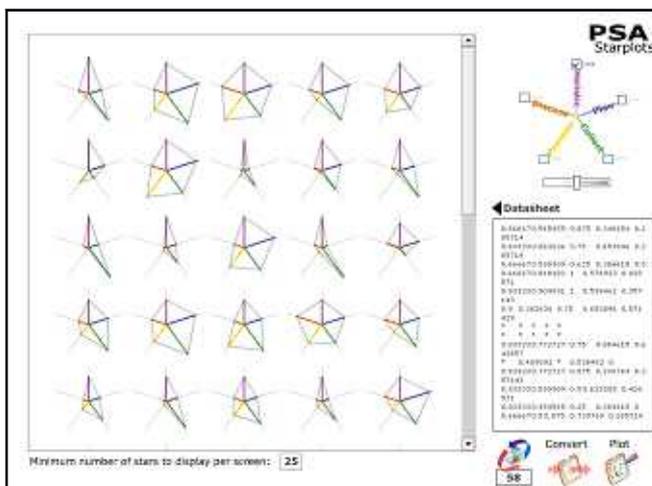
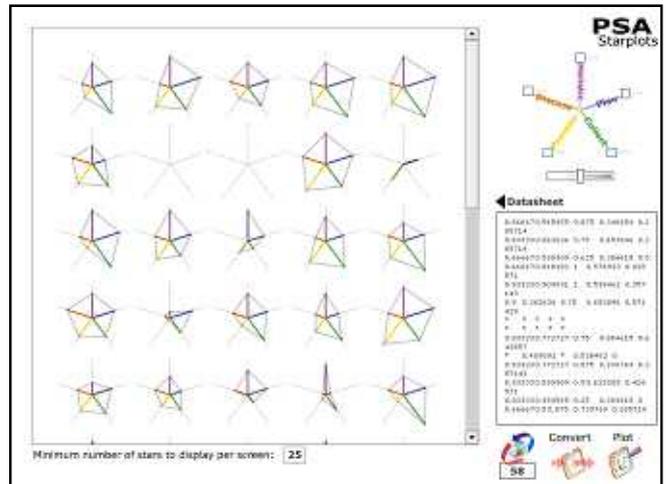
- Trialled with two year 8 (age 13) and one year 9 (14) group
- Student responses stored in a database
- Marking scheme adapted from the approach used by *Mathematics in Education and Industry* (MEI)
 - Each question scores 1 (correct), 2 (partially correct) or 0 (incorrect)
- Five domains:
 - Holistic (the idea) view of the PSA;
 - The Plan stage;
 - The Collect stage;
 - The Process stage;
 - The Discuss stage

V Assessment marking (D&D – drag & drop)

Assessment sheet for <i>Getting the Best Deal</i>					
Domain	Mark	Question	Description	Comment	Mark
Holistic view	0, 1, 2	A D&D	Places descriptions in correct locations.		
	0, 1, 2	A1	Clear statement of what cycle means and why it is important.		
	0, 1, 2	B D&D	Places statements into correct stages of the cycle.		
Ayesha Plan	0, 1, 2	B1 & B2	Gives a clear justification for choice of response to B1		
	0, 1, 2	B3	Correctly identifies the statement that is the problem to be solved.		
	0, 1, 2	B4	Gives a clear description of an alternative method that could be used to choose a day at random.		

VI Results

- Star Plots of domain statistical investigation process
- Distribution of marks
- Results by each of the 5 domains
 - holistic, plan, collect, process, discuss
- Results by age
- Conclusions

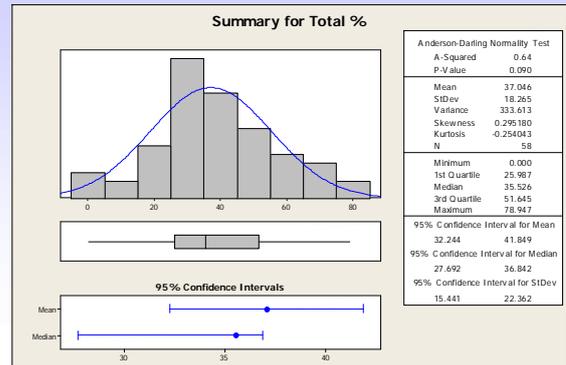


Interpretation of Star Plots of individual scores

- Star plots enable each student's scores to be viewed (and compared with others)
- Process and discuss arms of star plots short (low marks)
- Overall idea of PSA (holistic) was grasped

The results – overall performance

- The full range of marks was used

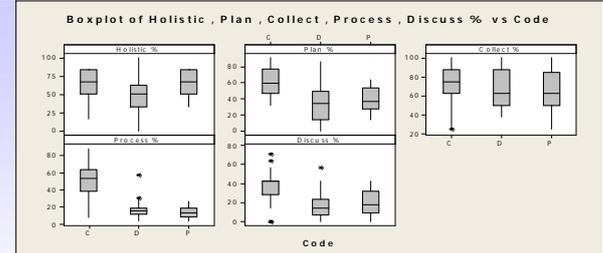


The results – by domain

Domain	N	Minimum	Q1	Median	Q3	Maximum
Holistic	55	0.00	50.00	50.00	83.33	100.00
Plan	56	0.00	27.27	45.45	59.09	90.91
Collect	54	25.00	50.00	68.75	87.50	100.00
Process	55	3.85	11.54	19.23	46.15	88.46
Discuss	54	0.00	12.50	21.43	42.86	71.43

- A wide range of marks observed for each domain
- Poor average performance overall in the 'Process' and 'Discuss' domains

The results – by age of student



- C is year nine group, D and P are year 8
- All groups have grasped the idea of the PSA (holistic domain) and performance is similar for the collect domain
- Younger students do less well in other domains

Analysis of different effects

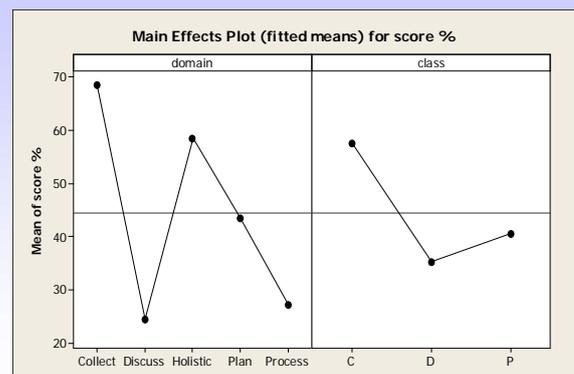
ANOVA

- Two way: class and domain
- Both main effects and interactions were significant ($p < 0.002$)
- Clear evidence of better overall performance by older students

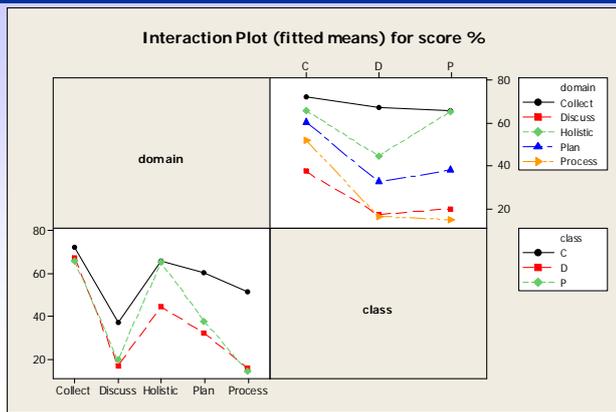
Effect plots show:

- Poorest overall performance in Process and Discuss domains
- Best overall performance by older students

ANOVA – main effects



ANOVA – interactions



Conclusions

- Assessment was well received
- Assessment did assess the PSA as intended
- There is evidence of age related performance
- BUT all students seemed to embrace the holistic view
- Need for a bigger in-depth study over a wider age range of students

THE LAST SLIDE

The End

Applications to undergraduate teaching

Support for Problem solving/case study scenarios in undergraduate teaching:

- Business and Industry - Stuart (2003)
- Agresti and Franklin (2009) provide excellent examples
 - Non-specialist students, typically HE level 1

Exemplar materials from the RSSCSE schools project provide a useful template for HE

Applications to undergraduate teaching

2001 enquiry into using data sets in HE

Commissioned by the Joint Information Systems

Committee Rice et al (2001) recommended:

- Promoting subject-based statistical literacy for students
- Corresponding support for teaching staff
- Development of high quality teaching materials using major UK datasets

Introducing statistics to undergraduate social science students

- Murtonen and Lehtinen (2003)
 - many social science students have problems with quantitative methods
- Williams et al (2004)
 - Crisis in the production of quantitative academic output in UK Sociology
 - A “societal problem of numeracy”

Economic and Social Research Council Response



Economic and Social Research Council Response

In 2006 there were calls for proposals to develop undergraduate curricula that:

- use real data to show the value of quantitative methods
- show students they have the foundation skills that can build on their school experience
- encourage students to collect their own data and analyse them
- encourage students to carry out their own research projects using data

Social Sciences and the PSA

- Approach social science problems through evidence-based decision making
- Teach the 'social scientific research method'
- Use the problem solving approach to engage HE students in real social science problems
- Employ real data collected by the undergraduates themselves
- Employ relevant secondary data and introduce undergraduates to UK social science data bases

Motivating/engaging new undergraduates

- New undergraduates will be concerned about the town where they are attending university
- Social Science students will, at some stage, consider the social effects of crime
- The 'How safe is your area' problem developed for the RSSCE/QCA project is an example that is of interest to social science undergraduates

The first quantitative methods lecture

- Introduce the problem
- Discussion
- Student questions
- Choose data
- Reminder of the PSA

Introduce the problem

Plan

Collect

Process

Discuss

How safe is the area you live in?

TV, radio and newspapers regularly report crimes and crime statistics.



Discussion

Are the crime figures as bad as some of the newspapers suggest?

Where in the UK is the 'safest' place to live?



In which areas of the UK is crime increasing?

What are the crime figures like in your area?

Are crime figures increasing each year?

Which places are improving?

Where is the 'crime capital' of the UK?

Should people be more/less concerned about certain crimes?

Questions of Interest

Plan

Collect

Process

Discuss

How safe is the area you live in?

When crime statistics are reported, newspapers and other media concentrate on *particular* crimes:

These are called the **Six Key Crimes**.

Burglary
Robbery
Sexual offences
Theft from a vehicle
Theft of a vehicle
Violence

Choosing data

Plan

Collect

Process

Discuss

How safe is the area you live in?

The question 'how safe is your area' can be looked at in two ways- by finding out the actual crime figures and by looking at how worried people are about crime.

Which approach will you use?

Local crime figures

Select

People's perceptions of crime

Select



The First Seminar/Workshop - Collect

- The students complete a short questionnaire (online)
- The questionnaire comprises
 - Three demographic questions including date of birth
 - Four questions taken from the British Crime Survey (www.statistics.gov.uk/ssd/surveys/british_crime_survey.asp)

The First Seminar/Workshop - Process and Discuss

- Students revise data summary presentation
 - use their collective seminar data for this
 - summarise their seminar group's perceptions
- Students draw tentative conclusions
 - limitations of the seminar 'sample' discussed
 - possibility of using the whole module group's responses in next seminar session discussed

The Second and Subsequent Lectures

- From the start the students have been involved in
 - the formulation of the problem being investigated
 - their own data being collected
- The impetus is maintained by
 - reminding the students of the PSA
 - using their data to illustrate the *Process* and *Discuss* stages of the PSA
 - just introducing the statistical tools/techniques they need *in the context of their data* and at the time it is required

The Second Seminar/Workshop

- **Process** – produce summaries for the whole cohort and subgroups
- **Discuss** - comparison of different perceptions with respect to
 - seminar group
 - gender
- Return to the questions raised in the lecture and refine the Plan
 - **Plan** how they would re-write the questionnaire and construct additional questions

Subsequent Seminar/Workshops What do other people think?

- **Plan and Collect**
 - Design their own questionnaire and Collect data by conducting a survey
- **Process** the survey data
- **Discuss**
 - Consider the results from their survey
 - Access the British Crime Survey data and compare with the perceptions from their sample

Subsequent Seminar/Workshops What is the crime profile of their area?

- **Plan**
 - Decide what are the key questions about the safety of their university town they want to answer and what data they need
- **Collect**
 - Secondary data sources, for example the Crime Statistics for England and Wales (www.crimestatistics.org.uk/output/Page1.asp)

Reference

John Marriott, Neville Davies and Liz Gibson (2009)

Teaching, Learning and Assessing Statistical Problem Solving

<http://www.amstat.org/publications/jse/v17n1/marriott.html>