Extended Project Teacher Guide: Investigation

Investigation/fieldwork: handouts

These are three handouts that you might want to distribute to students who are undertaking Investigation/fieldwork projects to supplement the materials in the Extended Project Student Guides/Companions.

Handout 1: What is an Investigation?
Provides a definition of the term 'investigation' and draws attention to the main defining feature of an Investigation/fieldwork Extended Project; it must involve the collection and analysis of some primary data.

Draw students attention to the note on 'extending yourself'. The project should not focus solely on the laboratory/fieldwork aspect, but should bring in ideas from other subject areas and show that students have developed a range of skills.

Handout 2: Investigation checklist
Provides a framework for planning and organising an Investigation/fieldwork project and supplements the material in the Extended Project Student Guides/Companions.

Handout 3: Safety and risk assessment
Draws attention to the need to carry out a risk assessment for any project that involves laboratory or fieldwork, including those that rely solely on collecting data using questionnaires. You need to supplement this handout with information relating to your own school/college's safety requirements, and with any forms that need to be completed.

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1. Questionnaires and surveys

This lesson is designed to help students design effective questionnaires for face-to-face and postal surveys and to draw attention to some of the pitfalls of questionnaire-based research.

Discussion 1: Designing a questionnaire (15 min)
Talking through the following points with students;

- Plan
- Time
- Questions
- Order
- Sample size
- Methodology
- Bias
- Timing
- Design
- Pilot

Draw attention to the point about methodology. If students are to collect their own data from the public using questionnaires they need to make sure that they are not contravening any laws or bye-laws about the use of public space, and are not doing anything that could be construed as trespass, nuisance or intrusion. The Market Research Society code of conduct provides some useful guidelines, though it is aimed primarily at commercial organisations.

Remind students that faced with a poorly worded or poorly designed questionnaire, people are likely to lose patience and fail to complete it or – worse – give random answers.

Activity 1: Good questions? (15 min)
For each of the questions below, ask the students to say why it is bad and suggest how it could be improved.

- Do you use the centre often?
- What mode of transport did you use to get to the centre?
- Why are you in this shopping centre?
- What type of shopping are you doing?

All the questions are too vague. Students should be able to suggest how they can be improved by avoiding vague or technical terms and providing a small number of closed responses such as the following.

How often do you use the shopping centre?			
More than 3 times a week	Once a week	Once a month	Less than 3 times per year

The boxes allow the information to be recorded easily. The first two options indicate that the shoppers are local. If someone is using the centre more than three times a week they are probably doing most of their shopping there rather than in the high street. If someone visits once a week, this could still indicate a threat to the high street.

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What was your main means of travel to the centre?					
Walk	Cycle	Bus	Car	Train	Other

It is likely that the first three responses indicate people from the local area, while 'car' indicates travel from an intermediate distance dependent upon the nature of the centre.

What is the purpose of your visit?				
Shopping	Cinema	Eating	Fitness	Other

If the response is 'shopping', this could indicate that someone is local, depending on the types of shopping they were undertaking – which will be the purpose of the next question. The response 'fitness' will almost certainly come mainly from local people.

What products are you buying?						
Food	Electrical	Clothes	Newspapers	Confectionery	Cosmetics	Other

This question would only be asked of people who responded 'shopping' to the previous question. Students should appreciate that a list like this would allow them to categorise shopping as 'high order' or 'low order'. Low order shopping (e.g. newspapers) is more likely to pose a threat to the high street shops.

Activity 2: Surveying the market (10 min)

Students should suggest reasons why the Spelthorne questionnaire they have been looking at would be hard to use. They should then discuss the advantages and disadvantages of using branching questions.

The students should appreciate that branching questions can provide useful information but that it is important that the questionnaire is well-designed so that relevant questions are not skipped over. It is also important that the directions are clear, particularly on postal questionnaires.

2-3. Describing and displaying data

This lesson will enable students to:

- use mean, median or mode where appropriate to describe data
- select a suitable type of chart or graph to display data
- know how to use Excel to produce graphs and charts

Discussion: Various variables (5 min)
It is useful first to establish some terminology for describing data. Students should appreciate the distinction between continuous, discrete and categoric variables.

Discussion: Descriptive statistics (10 min)
Students may already be familiar with mean, median and mode, but it is still revisiting when each should or should not be used.

There are several websites that provide useful guidance on descriptive statistics; the University of Leicester site is listed in the outline as an example.

Activity 3: Describing data (20 min)
Students should collect the following data from members of your class:

- Height
- Shoe size
- Number of brothers and sisters
- Method of travel from home to school/college (walk, cycle, bus, car, train, other)

For each set of data, they need to decide whether it would be possible, or meaningful, to use a mean, median or modal value, and then use the appropriate statistics to describe each set.

If you are short of time, you might decide simply to discuss this activity without students collecting any actual data. However, any data they collect will also be useful for Activity 4.

Discussion: Using Excel (15 min)
A key message here is that Excel should be used with caution, as it is all to easy to use it to generate graphs and charts that superficially look professional but are in fact of poor quality.

Activity 4: Displaying data (30 min)
Students need to decide how best to display each set of data that collected in Activity 3. They should explore the relationship between height and shoe size and decide what type of graph or chart would be suitable for displaying these two sets of data together. They should use Excel to produce graphs and charts of the data from Activity 3.

Ensure that students are able to make sensible choices about how to display data, and know how to use the Excel package effectively. They should pay attention to details such as labels and units on axes.

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4-5. Testing a hypothesis

These lessons will enable students to;

- use appropriate terminology relating to hypothesis testing
- understand what is meant by 'correlation'
- use the Spearman rank correlation test

Discussion: Defining terms (10 min)
This discussion could be illustrated by a real coin-tossing or dice-throwing experiment. If you can provide a biased coin or die (weighted so that it provides one outcome significantly more than others), so much the better.

Some students might find it quite difficult to follow what is going on and to relate to their own project work. In these instances it is best to move on from the theoretical discussion as things will become clearer when applied to an example.

Discussion: Correlation (10 min)
The Spearman rank test is introduced here as it is relatively simple to understand and apply, and has widespread use. However, it is only suitable for determining whether one set of data increases, or decreases, monotonically with another. It is not useful where there is peak in a relationship (e.g. between the launch angle and range of a projectile, or between time of day and temperature). Some students will need to learn about and apply more sophisticated tests.

A brief discussion should be enough to set the scene for the example.

Activity 5: Look at the data (15 min)
Student instructions:

Draw an *x*-*y* scatter graph using the data from Table 2. Plot body mass along the *x*-axis and ear length up the *y*-axis. (Do not join up the points.) Discuss whether there appears to be a correlation between the variables.
Harry and Hermione then used the formula for r_s:

$$r_s = 1 - \frac{6(d_1^2 + d_2^2 + \ldots + d_n^2)}{n(n^2-1)} = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)}$$

where n is the number of data pairs.

Their hypotheses were:
H_0: $r_s = 0$. There is no correlation between ear length and body mass
H_1: $r_s > 0$. There is positive correlation between ear length and body mass.
Here, $n = 8$ as there were 8 snaffles, so

$$r_s = 1 - \frac{6 \times 18.5}{8(8^2-1)} = 1 - \frac{111}{504} \approx 0.780 \text{ (3 s. f.)}$$

From statistical tables (Table 1), the critical value of r_s at this significance level for $n = 8$ is 0.643.
They therefore rejected H_0 and accepted H_1: at a significance level of 0.05 (95% confidence) there is a correlation between ear length and body mass for flop-eared snaffles.

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Harry and Hermione wondered whether there might also be a correlation between body mass and tail length. The data are listed in Table 3.

Table 3 Body mass and tail length

Snaffle	*Body mass/kg*	*Body-mass rank*	*Length of tail/cm*	*Tail-length rank*	d_i	d_i^2
A	50	2	14			
B	50	2	18			
C	50	2	18			
D	56	4	17			
E	59	5.5	13			
F	59	5.5	15			
G	60	7	19			
H	66	8	11			
					Total	

Teacher guidance:
Students should produce a quick hand-drawn graph and be able to 'eyeball' the data to see whether there appears to be a correlation. The graph shows some scatter, but there does appear to be a trend; this is confirmed by the calculation of r_s.

Activity 6: Look – more data! (10 min)
Student instructions:
Add another vertical axis to your chart from Activity 5. Label this axis 'tail length/cm' and use the data from Table 3 to plot points showing body mass and tail length. (Use a different colour to distinguish them from the body-mass points.) Discuss whether there appears to be a correlation.

Teacher guidance:
By adding the new data to their graph, students should be able to see whether there does, or does not, appear to be a correlation.

Activity 7: Correlation (20 min)
Student instructions:
Complete Table 3. Calculate r_s for body mass and tail length and hence decide whether there is a correlation between those variables. State your conclusion in terms of hypotheses and significance levels.

Teacher guidance:
It is worth spending a bit of time here ensuring that students know what to do with the data. The completed table is shown below.
Completed table for Activity 7

Snaffle	*Body mass/kg*	*Body mass rank*	*Tail length/cm*	*Tail length rank*	d_i	d_i^2
A	50	2	14	3	1	1.00
B	50	2	18	6.5	4.5	20.25
C	50	2	18	6.5	4.5	20.25
D	56	4	17	5	1	1.00
E	59	5.5	13	2	3.5	12.25
F	59	5.5	15	4	1.5	2.25
G	60	7	19	8	1	1.00
H	66	8	11	1	7	49.00
					Total	107

H_0: $r_s = 0$. There is no correlation between tail length and body mass
H_1: $r_s > 0$. There is a positive correlation between tail length and body mass.
For the data listed,

$$r_s = 1 - \frac{6 \times 107}{8(8^2 - 1)} = 1 - \frac{642}{504} \approx -0.274 \text{ (3 s. f.)}$$

Now r_s is less than the critical value of 0.643 for $n = 8$. Harry and Hermione must accept the null hypothesis H_0. At a significance level of 95%, (0.05), there is not a correlation between body mass and tail lengths.

Note that, although the calculated r_s is negative, this does not provide evidence for a negative correlation; that would require a calculated r_s beyond -0.643.

Activity 8: Join the dots? (5 min)
Student instructions:
Discuss whether joining the dots or drawing a trend line on your chart is valid in the case of (a) body mass and ear length (b) body mass and tail length.

Teacher guidance:
It would be reasonable to draw a trend line showing a possible relationship between body mass and ear length. However, it would not be sensible to draw such a line for the data on body mass and tail length; there is no significant evidence for correlation so a trend line would be meaningless.

6. In the river

The next 3 lessons focus on a case study of an Investigation project that can be used as a stimulus for discussion. The activities presented in these lessons address some generic points relating to Investigation projects.

The case study will help students plan and carry out an Investigation project. It will also allow them to discuss features of projects involving fieldwork and the collection of physical samples.

Discussion: In the river (5 min)
This case study illustrates some general features of a biology/geography/ecology-based Investigation. If students are at the stage of developing ideas for their own Investigations, the case study might help trigger some useful thoughts.

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Activity 9: That's the question (15 min)

Student instructions:

With a partner, discuss Anne's list of questions:

- Which questions would she need to address before carrying out her fieldwork?
- Which would help her identify 'milestones' for her project planning chart?
- Which might be answered using primary data from her fieldwork?
- Which provide some starting points for her Research review?
- Which could she discuss as part of the Analysis or Evaluation of her project?
- Which questions:
    - fit into the '5W' classification and need factual answers?
    - invite speculation?
    - might be addressed using ethical frameworks?
    - invite the expression of a point of view and the use of argument?

Teacher guidance:

Encourage lots of discussion. Students could write the questions on Post-it notes and group them into categories. The value of the exercise will be greatly enhanced if students each generate a similar list of questions and actions relating to their own projects.

The '5Ws' are a tool to assist them (Edexcel Level 3 Extended Project Student Guide, chapter 1). If they can set the scene it will improve the quality of their writing: What happened? Who was involved? Where did it happen? When did it happen? Why did it happen?

This is also a good point to remind students about the need for an Extended Project to demonstrate *extension*. All of the Awarding Body Extended Project guides/companions discuss how extension might be achieved. An Extended Project in Investigation has potential to demonstrate 'extension' in the areas of broadening skills, deepening understanding and widening perspectives.

Activity 10: Preparing for fieldwork (20 min + homework)

Student instructions:

Research some standard techniques for collecting and analysing data.

Visit the Field Studies Council (FSC) website and explore the free online resources for students, teachers and environmental professionals.

http://www.field-studies-council.org/publications/for-teachers-and-students/free-online-resources.aspx

Visit the British Ecological Society (BES) website and explore the education pages. Take a virtual tour of some ecological habitats and find out how they are studied.
http://www.britishecologicalsociety.org/

Teacher Guidance:

The BES and the FSC websites are excellent sources of ideas and information. On the FSC site, follow links to publications and to free online resources. The Education button on the BES site takes you to free wallcharts and other resources.

For students with a general interest in the area of biology/ecology/geography, the sites are a good source of topics for Investigation/fieldwork projects. It is worth taking time to explore the resources in some detail, as they illustrate methods of data collection and analysis that students will find useful.

7. Into the air

This lesson is designed to help students plan and carry out an Investigation project and to discuss the features of projects involving laboratory work

Into the air (5 min)
This case study exemplifies an Investigation centred on laboratory work. If students are at the stage of developing ideas for their own Investigations, the case study might help trigger some useful thoughts.

Activity 11: Extended Project (20 min)
Students should be able to identify several examples of 'extension' including:

- deepening understanding of the theory of electromagnetism
- widening perspectives by discussing ethics of weapons research
- broadening skills by learning new workshop techniques.

Activity 12: Laboratory work (15 min)
Key features of 'exemplary' laboratory work include:

- theoretical background
- use of appropriate apparatus
- consideration of safety
- calibration of measuring instruments
- testing of predictions
- control of variables
- consideration of experimental uncertainty/error
- mathematical expression of results
- comparison between results and predictions
- conclusions based on results
- conclusions related to research question.

These features are largely generic, so students undertaking any laboratory-based Investigation should be able to incorporate most or all of them into their own work.

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8. In the town

This lesson will help students plan and carry out an Investigation project and to discuss features of projects involving fieldwork and questionnaires

In the town (5 min)
This case study exemplifies an Investigation that uses surveys and questionnaires. If students are at the stage of developing ideas for their own Investigations, the case-study might help trigger some useful thoughts.

Activity 13: What to do? (35 min)
Student instructions:

In a group, discuss Ellie's suggestions (below) and say which you think would be worth pursuing, which could be adapted to be more useful (and how) – and which are probably not worth spending time on. Add any suggestions of your own. Remember that the project work must relate to the main

objective, and should also demonstrate 'extension' in terms of deepening understanding, broadening skills and widening perspectives.

Ellie's suggestions:

- Survey the cafe's weekend customers to find out whether they are local people or visitors and whether they would come to the cafe for an evening meal.
- Survey people visiting the town centre in the evenings to find out if they would visit the cafe, ask them what type of meal they would choose (snack, fast food, top-quality restaurant meal) and how much they would spend.
- Study the cafe's records to find out how much the average customer spends, and what types of food and drink lead to the highest profits.
- Interview the cafe owner.
- Cook some sample menus for evening meals, offer them to passers-by and ask for their opinions.
- Use Yellow Pages to find the locations of other cafes in the town
- Learn how to use a spreadsheet to model the cash flow of a business.
- Use textbooks to find out about theories of small-business management.
- Interview someone from the local tourist office to find out about patterns of visitors to the town.
- Find out about bank loans for business expansion.
- Research legislation relating to cafes and restaurants e.g. working hours, licensing, health and hygiene, wages.
- Make a market map of the area.
- Collect information about the menus and opening hours of other cafes and restaurants nearby.
- Visit websites that give advice about running a small business.

Ellie's work enabled her to produce a business plan for the cafe, and helped the owner to decide whether to serve evening meals.

Teacher guidance:
Encourage lots of discussion. Students should be able to identify some actions that are essential or useful (e.g. surveying people visiting the town centre in the evenings) and other that are probably a waste of effort (e.g. cooking sample menus and giving them to passers-by).

They should also appreciate that some of the useful actions would 'extend' the scope of the project (e.g. learning to use a spreadsheet to model cash flow).

It would also be worth discussing the practical implications of some of the proposed actions e.g. how would it be possible to go about surveying evening visitors?

Once you have discussed the case study, students should then be able to transfer some of their thinking to their own projects.