Accredited

LEVEL 3 CERTIFICATE

Scheme of work

H867

QUANTITATIVE PROBLEM SOLVING (MEI)

Statistical Problem Solving (MEI)

September 2015

MEI
Innovators in Mathematics Education

OCR
Oxford Cambridge and RSA

We will inform centres about any changes to the specification. We will also publish changes on our website. The latest version of our specification will always be the one on our website (www.ocr.org.uk) and this may differ from printed versions.

Oxford Cambridge and RSA Examinations is a Company Limited by Guarantee.
Registered in England. Registered company number 3484466.

Registered office: 1 Hills Road
Cambridge
CB1 2EU

OCR is an exempt charity.

The competence statements in the scheme of work below are from Statistical Problem Solving 90 glh component (Component 02 of Level 3 Certificate in Quantitative Problem Solving). This needs to be taught with Component 01 of Level 3 Certificate in Quantitative Problem Solving to make up a full qualification.

Competence statements in brackets are addressed in the relevant section but have been detailed in earlier sections.

Use of ICT is integrated throughout the scheme of work. The Statistical Problem Solving component includes a pre-release large data set which is available from OCR. It is expected that students will work with this data set throughout the course, using technology. It is also important that students are familiar with the statistical functions on their calculators.

This is a problem based scheme of work; the content is covered using investigations. All investigations are carried out using the Problem Solving Cycle.

Measures and location and spread (approx. 10 hours)

Overview

- This section revises measures of location.
- The sample standard deviation is introduced. (Also see the sampling methods section.)
- There are activities built into the resources to revisit some of the topics in Quantitative Problem Solving Component 01.
- Students should use the appropriate measures of location and spread based on the shape of the distribution and the problem to be solved.
- It is important that students clearly explain their investigation and methods used, clearly report their findings with recommendations for further research.
- Discussion on how to solve the problem should be encouraged.
- Each investigation offers opportunities for students to carry out further research.
- Students should be encouraged to use a calculator to calculate measures of location and spread.
- Correct use of notation should be encouraged.
- Instructions on how to use the statistical functions on a calculator are included in the resource Measures of Location and Spread.
- Using measures of location and spread is basic to most statistical work in many subjects such as economics, psychology, biology and in areas of work such as international charities, business and medicine.

Competence statements	Objectives	Resources	Examples of questions to promote thinking
SPSs17, 18, 19, 22	**Core** • Use standard statistical notation for samples. • Be able to use sample data to estimate the parameters of a distribution or the inputs for a procedure or model. • Be able to use the statistical functions of a calculator to find the mean and standard deviation. • Be able to substitute input values into a model or procedure.	**Integral resources – OCR (MEI) Level 3 SPS** Measures of Location and Spread Includes Using a Graphic Calculator **Other resources** These resources are external to the Integral website. National Stem Centre Spot the error National Stem Centre Descriptive Statistics Nuffield Music Festival **In the news** The Telegraph News story – Texts Mail Online Mr and Mrs Average	• Why is the mean not the appropriate measure of location to calculate if the variable under investigation is positively skewed? • Headline 'The average Briton texts two million words in their lifetime'. What is the shape of the distribution of words per text message? • CO2 emissions per capita 2012 **China** 5.53 Brazil 2.05 **India** 1.46 Russia 12.04 **Qatar** 49.05 Pakistan 0.97 • For these six values the mean is 11.85 what is the median? Are there any outliers? Explain how any outliers will affect the standard deviation. • The results of a survey asking a sample of 14 year olds how many friends they had reported a mean of 7.2 and a standard deviation of 10.0. This distribution had a median of 5 and a mode of 4. Based on these statistics, what could the shape of the distribution look like? Can you sketch a bar chart? • Investigate the shapes of distributions from the pre-release data set. Are there subsets of the data where comparisons using measures of location and spread would provide insight?

Linear transformations (approx. 8 hours)	**Overview** • This section naturally leads-on from the previous section. • Concepts are introduced on linear transformations of the mean and standard deviation for a sample; this idea will be used in the section on the Normal distribution. • Students will not be expected to provide algebraic proofs or express transformations in an algebraic form. • Students need to understand the effect on the mean and standard deviation of a sample, or a distribution, when an amount is added to each term in the distribution or each term is multiplied by an amount or a percentage. • Examples of when using a datum level is appropriate are introduced here. • Datum levels are used in construction, geography and environmental studies. • Linear transformations of distributions are used when comparing measurements with different units or to get measurements onto a standard scale. This is used in manufacturing, for quality control and in science and finance.		
Competence statements	**Objectives**	**Resources**	**Examples of questions to promote thinking**
SPSs20,21	**Core** • Understand the use of a datum level as a base for measurement or calculation. • Know how the mean and standard deviation are affected by linear transformations.	**Integral resources – OCR (MEI) Level 3 SPS** Linear Transformations	• Marks on a difficult exam have a mean of 57 and a standard deviation of 20. The teacher boosts all the scores by 20 marks before awarding the grades. State the mean and the standard deviation of the new marks. • The annual income for a sample of Australian research assistants has a mean of 83,450 Australian dollars (AUD) and a standard deviation of 9,670 AUD. Values are converted to British pounds. At the time of conversion one British pound equalled 2.12 AUD, what is the mean and standard deviation of the annual income for this sample expressed in pounds? • Do linear transformations change the shape of the distribution? Explain your reasoning. • Why is it important to use a datum level when measuring sea levels? • State other situations where the use of a datum level is necessary. • Choose a numerical variable from the large data set. Investigate how different linear transformations affect the histogram, mean and standard deviation.

The Problem Solving Cycle (approx. 14 hours)

Overview

- This section revisits the Problem Solving Cycle by carrying out investigations that use real data.
- Students should be encouraged to discuss each stage of the Problem Solving Cycle.
- Students should clearly state the problem, question or investigation and plan how to collect the data. Sometimes this will involve identifying appropriate secondary data which has been collected by someone else.
- Students are encouraged to collect suitable data and reflect on the validity of their data.
- Students should use appropriate methods of presentation and process rather than a collection of techniques to solve the problem, or answer the question. It is recommended that reasons for each choice should be given.
- It is important that students report their findings clearly with a discussion of the strengths and weaknesses of their investigation.
- Students should be encouraged to state ideas for further research.
- There are many competence statements in this section as the Problem Solving Cycle is the basis for this component.
- Teachers may wish to do part of this section now and part after the Normal distribution or hypothesis testing. Alternatively, the shape of the Normal distribution (from IQR) can be revisited here.
- There are activities built into the resources to revisit some of the topics in Quantitative Problem Solving Component 01. For example Graphing Activity, Types of Variables which are part of the resource 'The long and the short of it'.
- Each problem offers opportunities for students to carry out their own investigations.
- Statistical problem solving is the basis of statistical research carried out in universities and in business – market research and investigations in sociology and psychology are examples.

Competence statements	Objectives	Resources	Examples of questions to promote thinking
SPSs1,2	• Be able to formulate a problem in a way that lends itself to statistical approaches. • Consider different statistical approaches to the problem.	**Integral resources – OCR (MEI) Level 3 SPS** The Problem Solving Cycle – The long and the short of it. Includes: Graphing Activity Types of Variables Problem Solving Checklist	• Are professional women footballers taller than the average woman? • During international matches do rugby players run further than football players? • Are pet owners are more sociable than people who do not own pets? • Should outliers always be removed from the data? • State some examples when it would be necessary to analyse the extreme values of a distribution. • What is the appropriate graph to plot to inspect the shape of the distribution of the weights of 1000 euro coins?
SPSs3,4,5	• Be able to select an appropriate standard distribution as a model. • Recognise where a standard statistical procedure may be used. • Be aware of any modelling assumptions involved in using a distribution or procedure that has been selected.		
SPSs6,7	• Be able to identify what inputs a model requires. • Be able to design a procedure for collecting the necessary input data for a model.	Is this a valid argument? This is identical to the resource of the same name in the Critical Maths resources	

Competence statements	Objectives	Resources	Examples of questions to promote thinking
SPSe1,2	• Be able to call on factual general knowledge. • Be able to make reasonable estimates of quantities met in everyday life without additional information.	**Other resources** These resources are external to the Integral website. CensusAtSchool How old is your height CensusAtSchool Height Investigation **Data links** Olympic.org Olympics data Dove Research Paper for comment **Data** The busiest airports Luminocity **Interpretation of data visualisation** British Social Attitudes	• Search some publications and find an example of a graph that is misleading or non-representative of the data it represents. Summarise what is wrong with the graph and explain how it could be improved. • What is the appropriate graph to plot to investigate if there is a relationship between the age and height of adults? SAS Curriculum Pathways • Compare differences in life expectancies between 2010 and 2013 for the worldwide populations. SAS Curriculum Pathways • Examine the number of households in the United States that have landline telephones, wireless telephones, or both from July 2010 to December 2013. SAS Curriculum Pathways • What is the average age of world leaders? How do the fixed term leaders ages compare to life time leaders (ie presidents, prime ministers to rulers, royal leaders)? Wikipedia infoplease • Investigate marital status by age group and sex, England and Wales, 2002 to 2014. • Office for National Statistics (first or second reference table). • What types of variables are included in the large data set? • What questions could you investigate using the large data set?
SPSs10,11,12	• Be able to find and use relevant information from a variety of sources. • Be able to evaluate critically information in public statements such as news reports and political comments. • Be able to understand accounts of statistical work done by others and comment on the quality.		
SPSs13,14	• Be able to select suitable techniques for processing raw data. • Be able to clean data including dealing with missing data and outliers.		
SPSs15,16	• Be able to select suitable data displays and summary measures to show the main features of the raw data. • Be able to use data displays to check whether distributions being used are realistic.		
SPSs23	• Be able to interpret the proposed solution in terms of the original problem.		
SPSs25,26	• Recognise when the proposed solution is unreasonable. • Be able to identify and comment on possible sources of bias or error which may have affected the solution to the problem.		
SPSs27,28,29	• Recognise when the approach taken needs to be refined or replaced. • Be able to propose a refined or new approach. • Recognise that a "good enough" solution to a problem can save time and money compared to a more accurate solution.		
SPSs30,31	• Recognise when additional data collection would enable a better solution to a problem. • Be able to communicate the solution to someone who understands the problem.		

The Normal Distribution (approx. 10 hours)	**Overview** • Building on the topics in Quantitative Problem Solving Component 01, this section concentrates on recognising and modelling Normal distributions to predict probabilities and to solve problems. • Much of the introductory work for this section is covered in the previous section on the Problem Solving Cycle. • The resource 'Too short to be a footballer?' includes worksheets with examples and questions not connected to the main problem. These are included to help students learn how to calculate probabilities for a Normal distribution. From this base students should be able to recognise a Normal distribution, know the parameters they need to calculate or use, and be able to calculate probabilities to solve a problem. • Probability plots are introduced in 'Too short to be a footballer?' This will be a new topic for most students. How to plot probability plots is included in the Teachers' Notes for 'Too short to be a footballer?' and 'The mathematics of business and finance: Modelling the Market'. Students will not be asked to calculate the points or plot the graph. Only interpretation of the plot will be assessed. • Students should be encouraged to use a calculator to find Normal probabilities. • The Normal distribution has many applications in manufacturing quality control, biology, medicine, science and social science.		
Competence statements	**Objectives**	**Resources**	**Examples of questions to promote thinking**
(SPSs 1–7) **(SPSe 1,2)** **(SPSs10–23)** **(SPSs23,26–31)** SPSu 1,2,3	**Core** **(PROBLEM ANALYSIS)** **(REPORTING/INTERPRETATION)** • Be able to use the Normal distribution as a model and recognise when it is likely to be appropriate to do so. • Be able to standardise a value from a Normal distribution with a given mean and standard deviation. • Use the Normal distribution to estimate population proportions in the context of the problem.	**Integral resources – OCR (MEI) Level 3 SPS** The Normal Distribution and Probability Plots – Too short to be a footballer? The mathematics of business and finance: Modelling the market (part 2) This resource is also part of the Integrating Mathematical Problem Solving resources **Other resources** These resources are external to the Integral website. National Stem Centre Measures of Centre and Spread This is a very good simple (childish) explanation on how to calculate measures of spread. National Stem Centre Stature Students investigate simulated stature data for men and women in eight countries as manufacturers need to take these into account when they design products. National Stem Centre The Coffee Problem CensusAtSchool Is our height Normal? What does the Normal Distribution Sound Like? The Normal Distribution	• If you are given a sample of the biomass of cockles (the total quantity or weight of organisms in a given area or volume) how would you go about deciding if the distribution was Normally distributed? • For an exam given to a class, the students' scores ranged from 34 to 98, with a mean of 74. Which of the following is the most realistic value for the standard deviation? -9, 0, 3, 12, 63? Clearly explain what is unrealistic about all the others. • During one shift a sample of cakes for a particular food producer was analysed. It was found that the average length of the cakes was 79 cm with a standard deviation of 1.96 cm. Cakes are rejected if they are less than 75 cm and more than 85 cm. Based on this sample what proportion of cakes would be rejected? • Are any of the numerical variables in the large data set Normally distributed? Are any definitely not Normally distributed? What makes you think this?

Sampling Methods (approx. 10 hours)	**Overview** • This section investigates how to select samples using different sampling methods. This is basic to all statistical work and important in business, politics and journalism. • The approach is to encourage students to take part in practical activities, using software, to investigate the advantages and disadvantages of different sampling methods. • The ideas of bias and error are introduced and discussed. • The idea of sample size is also important and can be demonstrated and discussed using the spreadsheet in 'Money Making Movies' and 'Love or Football?' to help select a representative sample. • Students should be encouraged to use a calculator to calculate measures of location and spread.		
Competence statements	**Objectives**	**Resources**	**Examples of questions to promote thinking**
(SPSs 1–7) **(SPSe 1,2)** **(SPSs10–19)** **(SPSs23,25–31)** SPSs 8,9	**Core** **(PROBLEM ANALYSIS)** **(REPORTING/INTERPRETATION)** • Understand sources of variability in data and their implications in the context of a model and its inputs. • Know and be able to use suitable sampling methods in appropriate contexts. Sampling methods include: o opportunity sampling o simple random sampling o stratified sampling o quota sampling o cluster sampling o self-selected sampling.	**Integral resources – OCR (MEI) Level 3 SPS** Sampling Methods – Money Making Movies Experiment Design – Love or Football **Other resources** These resources are external to the Integral website. Core Maths Support Programme Population Data (This is a series of seven linked lessons that provide the basis for an extended piece of statistical work based on population data. All seven lessons make use of population data sets available from the Population Research Bureau.) Nuffield Parking Permits Sampling: Simple Random, Convenience, systematic, cluster, stratified – Statistics Help Effect of Sample Size A simulation in Excel CensusAtSchool Stratified Sampling ICSE Sampling Methods	• Headline: 20 % of men do not know the date of Valentine's Day. Fifty men between the ages of 24 and 38 were polled. Comment on the headline. • One year a UK social survey asked "How many good friends do you have?" Of the 624 adults who responded to this postal survey, 4 % reported having only one good friend. State the a) population, b) the sample c) the statistic reported. What type of sample is this? • Explain the difference between an exit poll and an opinion poll. • Explain why it is important to use randomisation wherever possible when sampling. • A local register has 400 names. Explain how you would use random numbers to select a simple random sample of 25 names. • Give an example of a survey that would be unrepresentative due to a) sampling method used and b) response bias. • You wish to find how many of the pupils at your school watch X Factor. A sample of 50 children is taken from your school's register so that every sample of size 50 has an equal chance of being selected. What type of sampling method is this? • You wish to investigate the number of texts pupils at your school send every day. You choose a class of 30 pupils in year 11 as part of your sample. What type of sampling method is this?

Hypothesis tests and Correlation (approx. 10 hours)	**Overview** • This section introduces the concept of a hypothesis test. Hypothesis tests are used in medical, educational and social science research so it is useful for all citizens to have some understanding of the underlying principles behind hypothesis testing. • The resource 'Are we equal?' introduces Spearman's Rank correlation coefficient and explains how to apply a hypothesis test on the correlation coefficient. • The ideas of the level of significance and the critical value are demonstrated and clearly explained in 'Are we equal?' • Students are expected to be able to calculate Pearson's Product Moment correlation using a calculator, and to interpret this. • Students are NOT expected to calculate the product moment correlation coefficient using a formula. • Encourage students to use a calculator to calculate correlation coefficients.		
Competence statements	**Objectives**	**Resources**	**Examples of questions to promote thinking**
(SPSs 1–8) **(SPSe 1,2)** **(SPSs10–19)** **(SPSs22,23, 25–31)**	**Core** **(PROBLEM ANALYSIS)** **(REPORTING/INTERPRETATION)**	**Integral resources – OCR (MEI) Level 3 SPS** Correlation and Hypothesis Tests-Are we equal? Take your partners This resource and the one below are part of the Integrating Mathematical Problem Solving resources – these are freely available on Integral The mathematics of psychology: Correlational study **Other resources** These resources are external to the Integral website. Core Maths Support Programme The best song ever University of Otago Maui's Dolphin: Uncovering a new subspecies Spurious Correlations	• A news story starts "Scottish neighbourhoods with the most licensed premises have the highest rates of alcohol-related illness and deaths, according to a new study." Do you think there is a causal relationship here and, if so, what is causing what? • Does the increased availability of alcohol increase the rate of related problems or do businesses open where there is more custom? • Is it possible to design a way to find out? • Is there a correlation between the food rating for a London restaurant and the average cost of a meal at that restaurant? Interpret your findings. Zagat restaurant guide. • It is reported, based on a sample of students aged between 11 and 16, that taller children have a better vocabulary. Is there a causal relationship, whereby being taller gives you a better vocabulary? • What variables in the large data set do you think are correlated? Can you check this?
SPSh1,2	• Understand the process of hypothesis testing including using the associated vocabulary. o null hypothesis, alternative hypothesis o significance level, p-value o 1-tail test, 2-tail test o critical value o critical region o acceptance region, rejection region. • Be aware that large data sets can be representative of underlying populations and can be used to draw conclusions.		
SPSb1,2,3	• Know the vocabulary associated with bivariate data: association, correlation, line of best fit, dependent variable, independent variable. • Know how to calculate Spearman's rank correlation coefficient and carry out hypothesis tests using it. The null hypothesis is that there is no association between the variables. • Be able to use suitable technology to find Pearson's product moment correlation coefficient and to interpret the correlation coefficient.		
SPSs24	• Be able to interpret the results of a hypothesis test in terms of the original problem.		

<table>
<tr><td>Chi-squared hypothesis test (approx 10 hours)</td><td colspan="3">Overview
This section introduces the Chi-squared significance test. This is used in social sciences and biology to investigate whether there is association between categorical variables.
Only the Chi-squared test for independence (contingency tables) will only be assessed in this qualification (not goodness of fit).
The resource 'Don't Drink and Drive' introduces and explains when and how to carry out this test.
Students can be asked to calculate expected values and the Chi-squared statistic.
Clearly stating the hypothesis and linking their findings to this is very important.</td></tr>
<tr><td>Competence statements</td><td>Objectives</td><td>Resources</td><td>Examples of questions to promote thinking</td></tr>
<tr><td>(SPSs 1–8)
(SPSe 1,2)
(SPSs 10–19)
(SPSs 22,23, 24, 25–31)
(SPSh 1,2)
SPSh3,4</td><td>Core
(PROBLEM ANALYSIS)
(REPORTING/INTERPRETATION)
Be able to apply the χ2 hypothesis test to data in a contingency table. Including calculating the contributions of individual cells to the test statistic. The null hypothesis is that the classifications used for the rows and columns are independent.
Be able to interpret the results of a χ2 test. This may involve considering the individual contributions to the test statistic.</td><td>Integral resources – OCR (MEI) Level 3 SPS
Chi-squared Hypothesis Test-Don't Drink and Drive
The mathematics of biology: Statistical testing in medicine
This resource is part of the Integrating Mathematical Problem Solving resources – these are freely available on Integral
Other resources
These resources are external to the Integral website.
Thinking Quantitatively II
The Chi-Squared Statistic
Contingency tables and Chi-squared Distribution</td><td>Is there an association between gender and country for selfies taken? Images
Is there an association between mood (smiling/not smiling) and country for selfies taken? Images
Is there an association between the superpower children would like to have and gender?
<table><tr><td>Super Power</td><td>Fly</td><td>Invisible</td><td>Super Strength</td><td>Telepathic</td><td>Freeze Time</td></tr><tr><td>Girls</td><td>38</td><td>20</td><td>2</td><td>21</td><td>29</td></tr><tr><td>Boys</td><td>30</td><td>13</td><td>17</td><td>10</td><td>43</td></tr></table>
What type of data is needed to carry out a Chi-squared test?
Can you give an example of a hypothesis which could be tested using a Chi-squared test?
What does a significant result in a Chi-squared test imply?
What would a chi-square significance value of $p > 0.05$ suggest?
Are the two variables, gender and ethnicity, most likely to be independent or dependent?
Is the Chi-squared test for independence a one-tailed or two-tailed test?
How would you explain what the expected values are?</td></tr>
</table>


We'd like to know your view on the resources we produce. By clicking on the 'Like' or 'Dislike' button you can help us to ensure that our resources work for you. When the email template pops up please add additional comments if you wish and then just click 'Send'. Thank you.

If you do not currently offer this OCR qualification but would like to do so, please complete the Expression of Interest Form which can be found here: www.ocr.org.uk/expression-of-interest

OCR customer contact centre
General qualifications
Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk