Example Marking Schedule: Use Statistics to Make an Inference (Mathematics and Statistics AS 2.9)

Evidence/Judgements for Achievement	Evidence/Judgements for Achievement with Merit	Evidence/Judgements for Achievement with Excellence
The student shows evidence of using **<u>each</u>** component of the statistical enquiry cycle to make an inference.	The student will make an inference, showing evidence of linking each component of the statistical enquiry cycle to the **context, and/or populations** and referring to **evidence in support** of statements made.	The student will make an inference, showing evidence of **statistical insight** which involves integrating contextual and statistical knowledge throughout the statistical enquiry cycle, or reflecting about the process, or considering other explanations.
Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard		
The question is **comparative** and identifies two groups and **the population** from which the samples are to be taken. *Did the median number of days sick for Year 9 students tend to be fewer than the median number of days sick by Year 10 students in ABC High School for 2011?* The variable being examined is stated directly in the question (Not "are Year 9 students sicker than Y10 " etc.) and its measured parameter (i.e. median). The population must be specified correctly, and not assumed to be wider than the group actually tested (e.g. not "students" if only Hamilton students were sampled). A hypothesis should be offered e.g. *I predict that …*	The question asked is comparative and identifies two groups and the population from which the samples are to be taken. **The purpose of the investigation is specified or the question is linked clearly to the situation being investigated**: *Did the median number of days sick for Year 9 students tend to be fewer than the median number of days sick by Year 10 students in ABC High School for 2011?* *I predict that the Year 9 students will have less sick days.*	The question asked is comparative and identifies two groups and the population from which the samples are to be taken. The purpose of the investigation is specified and the question is linked clearly to the situation being investigated: *Did the number of days sick for Year 9 students tend to be fewer than the number of days sick by Year 10 students in ABC High School for 2011?* *I predict that the Year 9 students will have less sick days because they don't yet dislike school as much as Year 10 students and aren't as good at getting days off.*
Random samples from each group are selected. The samples are sufficiently large e.g. 30+ for each group. Sampling method need not be stated. Sampling process does not need to be detailed but the sample size must be clear. Some indication of the sample values is included. *By using the simple random sampling method I am going to select a sample of 30 Year 9 students and a sample of 30 Year 10 students from the records of ABC High School for 2011.*	**An appropriate** random sample of at least 30 from each group has been generated and the corresponding population data collected. This can be implied and the process does not need to be written. Contextual reasons have been given for deciding on the use of a simple random sample **or** the sample size. *By using the simple random sampling method I am going to select a sample of 30 Year 9 students and a sample of 30 Year 10 students from the records of ABC High School for 2011.* *I will use a sample of size 30 for each group as this should give me enough information about the number of sick days by each group to ensure that the samples for each group are unbiased and representative of the whole population.*	As Merit but contextual reasons have been given for deciding on the use of the sampling method **and** size. *By using the systematic sampling method based on the order of their last name I will select a sample of 30 Year 9 students and a sample of 30 Year 10 students from the records of ABC High School for 2011.* *I will use a sample of size 30 for each group as this should give me enough information to be confident in my conclusions, with a sufficiently small confidence interval.* *I will use systematic sampling because it is quick. I cannot see any obvious strata to separate on to use stratified sampling. I hope that using last name will allow a representative and unbiased spread based on any groupings that might be based on last name.*

Sample statistics correctly calculated. Sample medians (with informal confidence intervals) and quartiles must be calculated (or implied by the box plot) for each group. A dot plot and box and whisker graph plotted for each set of sample data. (N.B. box and whisker graph must show informal confidence interval.) *For my sample, statistics are* *Year 10s: mean = 8.2, median = 4, Upper Quartile = 6.5, lower quartile = 2,max= 55, min=0, Interquartile range = 4.5, Range = 55, Informal confidence interval = ±1.23* *Year 9s: mean = 6.4, median = 3, upper quartile = 8, lower quartile = 1, IQR = 5, max = 45, min = 0, range = 45 Informal confidence interval = ±1.37*	Sample statistics including sample medians and quartiles have been calculated (or implied by the box plot) for each group. A dot plot and box and whisker graph with informal confidence intervals calculated and plotted for the population medians. *Informal Confidence Interval:* *Year 10* $4 \pm 1.5 \times 4.5 \div \sqrt{30}$ *Year 9s* $3 \pm 1.5 \times 5 \div \sqrt{30}$	Sample statistics including sample medians and quartiles have been calculated explicitly for each group. A dot plot and box and whisker graph plotted for each group with informal confidence intervals calculated and plotted for the population medians. Another graph plotted, if appropriate.
Sample distributions have been discussed with at least two comparative features of the sample distributions (shape, overlap, shift, spread, middle 50%, unusual or interesting features) identified. Comments must be correct in terms of the student's statistical analysis and graphs. *The median of the number of Y10 sick days is above the median number of sick days for Y9 students.* *Looking at the box and whisker graph we can see that there is quite an overlap of IQRs.* *Both sets of data are skewed very high by a couple of very large values (e.g. 55 sick days for one Y10 boy).*	Sample distributions have been discussed with at least two comparative features of the sample distributions (shape, overlap, shift, spread, middle 50%, unusual or interesting features) have been identified and **comments have been linked to the investigative question** and the population. Comments must be correct in terms of the student's statistical analysis and graphs. *The median of the number of Y10 sick days is above the median number of sick days for Y9 students.* *Both sets of data are skewed to the right in the same way. The maximum values are very high, but also the UQs are further from the median than the LQs.* *The mean number of sick days is very different from the median, as a result.*	The student shows **clear thinking and statistical insight** when discussing the sample distributions, integrating statistical and contextual knowledge. Comments must be correct in terms of the student's statistical analysis and graphs. *At every point on the 5-points of the box and whisker, the Year 10 value is at least as high as the Y9 value.* *Both sets of data are skewed to high values in the same way. This suggests a similar sort of pattern is operating in Years 9 and 10 of being sick, which you would expect. This is because a lot of boys have only a few sick days, and then a few boys have a lot.* *A result of the asymmetry is that the mean is quite a lot higher than the median (while we would expect the mean to equal the median in a symmetric distribution).* *The maximum values are a long way from the medians but there is no reason to believe they are outliers. It is quite reasonable for boys to lose a lot of time if they are very sick. The result of these is to strongly drag the means to higher values, but the effect on the medians is zero, as they are not affected by extreme values.*

Discussed that different samples will give different intervals or indicated estimates of population parameters. *These results reflect my sample. If other samples were taken they would use different values and so the results and graphs would be different. If I took more samples I might be able to tell what it was like it in the population.*	Discussed that different samples will give different intervals or indicated estimates of population parameters. The **effect of at least one aspect**, for example, sample size, **has been considered**. Comments, in context, must **relate to the informal confidence interval** and **refer to expectations** about whether the population median would be contained in it *I would expect that if I took more random samples I would get different statistics and that the informal confidence intervals would be slightly different to this sample.* *The true median number of sick days in Year 9 is likely to be within the range of xx – xx.*	Discussed sampling variability, including variability of estimates. Must note the fact that different samples will give different intervals or estimates of population parameters has been indicated. The effect of **both** aspects, for example, sample size, should be considered. Comments, in context, must relate to the informal confidence interval and refer to expectations about whether the population median would be contained in it. Comments should show high level of understanding or statistical insight. *If a larger sample size were used the variability from sample to sample would be reduced and the informal confidence interval itself would be smaller giving a more accurate interval for estimating the population median.* *The effect of larger sample size would be greater for the mean, because it would reduce the effect of one or two very large values in a small sample. I would want a larger sample size before I was confident the mean was an accurate estimate of the population mean.*
Made a correct inference. Stated, in context for at least one case, a valid conclusion about a population statistic and justified by reference to an inferential rule. *From my data I cannot make the claim that the number of sick days by Year 9 students is less than the number of sick days of Year 10 students. There is too much variation in the values (seen by the way the IQRs are so large compared to the difference in the medians).*	Made a **supported** correct inference that is stated, in context, for both sets of data **AND** stated a belief that the population median will lie within a correctly calculated interval or that the sample medians are estimates of the population medians. *All these statistics are only estimates for the entire population.* *As the informal confidence intervals do overlap I cannot say with confidence that the median sick days for Year 9s is smaller than the median sick days for Year 10s at this school.*	Made a **supported** correct inference that is stated, in context, for both sets of data **AND** stated a belief that the population median will lie within a correctly calculated interval or that the sample medians are estimates of the population medians. *All these statistics are only estimates for the entire population.* *As the informal confidence intervals do overlap I cannot say with confidence that the median number of Year 9s sick days is less than the median number of sick days for Year 10s at this school.* *The shape of the box-and-whisker plots indicate that the data is consistent with Year 10s being sick more.* *Considering the size of the Confidence Intervals, I am confident that Year 9s are not sick **more** often than Year 10s (the **reverse** of my hypothesis).*

Communicated findings clearly. The written report covers all the above bullet pointed aspects of the statistical enquiry cycle to the depth indicated by examples. An answer to the investigative question must be given and comments must be in context. Comments should be consistent with the analysis provided and make **reference to the population**. *From my sample results I cannot say confidently that Year 10 have a higher number of median sick days than Year 9s do at this school.*	Communicated findings clearly, has linked findings to the **context** and **populations**. T he written report covers all the above bullet-pointed aspects of the statistical enquiry cycle to the depth indicated by examples. An answer to the investigative question must be given and comments must be in context. Comments should be consistent with the analysis provided and make **reference to the population**. An understanding of the difference between the sample calculations and population estimates is demonstrated. Conclusion must be justified with reference to the informal confidence interval. *All these statistics are only estimates for the entire population.* *From my sample results I think that more sampling would be required to show confidently that Year 10s are sick more often than Year 9s.* --- <u>Excellence continued</u> *It would be interesting to see if there are more patterns inside a year, rather than between years.* *e.g. does a student who is sick a lot in Year 9 tend to be sick a lot in Year 10?* *e.g. are there certain groups of students who tend to be sick more often?* *The results we have are only for one school. It would be interesting to continue the study to other schools, to see if there is any effect in general. If the Year 10s in every school are sick more often we would have more confidence than if the effect only occurs in 50% of schools (i.e. by random).*	Communicated findings clearly, linked findings to the context and populations and shown statistical insight.. Students could reflect on the investigation process, the sampling process, the effect of aspects such as the sample size on the estimate, limiting factors in the definition of the groups, or identified the impact of other factors on the reliability of estimates. *From my sample results I think that more sampling would be required to show confidently that median sick days for Year 10s is higher than that for Year 9s, as the confidence intervals for the medians overlap.* *If I was to repeat this sampling process and to take another sample from the 2009 Cell Phone survey data set, I would get different data and expect to see different results to those I have now – different medians, quartiles, minimums and maximums as the sample data values I have selected would be different. It is possible that one of these samples could have a confidence interval did not overlap. However, it would be wrong to just take that one set of samples of evidence, as you cannot keep testing until you get the result you want.* *If you multiply the sample size by 4 the confidence interval will only decrease by a factor of a half, and to get it to one tenth requires 100 times as many sampled e.g. √4 = 2 and. √100 = 10 so it would take quite a lot of sampling to be confident of a difference between the Years.* *Our survey only includes students that finished year 2011 at the school. It is possible that the students who are sick most often tend to not finish the year.* *There is no test between actually sick and pretending to be sick. It may be that Year 9s are actually sick more often but pretend less, or the other way round, but we have no way to distinguish the two different situations.* ← Continued