The full version of the coding scheme for the VASM questionnaire

1. Views about the nature of scientific knowledge

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A00	-	(no reason given).
A01	12	(not able to code response given).
A10	7	Scientific knowledge is based on facts.
A11	1	Scientific knowledge is obtained from observations.
A12	84	It is knowledge that explains/describes the behaviour of nature/system.
A13	-	It is knowledge that does not involve personal opinion/bias.
A14	-	Knowledge in science is concrete compared to other knowledge which is abstract.
A20	22	It involves experiments.
A21	13	It is knowledge based on evidence.
A22	9	It has to be proved by an experiment.
A23	6	It is obtained by using the scientific method.
A30	-	It is knowledge that can be modified/changed with new information.
A31	-	It is always being expanded/improved with new information.
A40	-	It includes human inference.
A41	3	It involves logic.
A42	-	It includes the use of creativity and imagination.
A43	-	The use of previous knowledge is also required.
A44	-	It is socially and culturally embedded.
A45	1	For knowledge to be considered as scientific it has to be validated by a scientific community.
A50	-	It has limitations. It is only an approximation of what is observed in nature.
A51	-	It is a model/representation of nature.
A60	3	It includes theories/laws.
A61	7	It involves calculations/mathematics/formulae.
A70	-	It leads to further predictions.
A71	2	It leads to improvements/provide solutions to problems.
A72	1	It is reliable/advanced/complex.
A80	4	It is knowledge obtained from maths/physics/biology/chemistry.

2. You now think about what scientists do

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A		**Nature follows exact laws and scientists discover these laws because…**
A00	1	(no reason given).
A01	10	(not able to code response given).
A10	23	nature already has its laws/rules. Scientists have to research/prove and explain them.
A11	-	science deals with facts.
A12	-	science is about what is observed in nature.
A13	-	science is the quest for the truth about nature.
A14	-	scientists cannot change laws of nature.
A20	1	scientists need to provide reasons for the behaviour of nature.
A21	1	scientists explore and learn more about the laws/theories.
A30	-	scientists perform experiments to prove the laws or theories/the behaviour of nature.
A40	-	scientists help to improve the world/find solutions to problems.
A80	1	theories are simpler ways of putting together what scientists have gathered from experiments/nature/observations for better understanding.
A90	1	scientists discover the laws of nature and also construct theories.
B		**No, scientists construct theories to explain what they observed in nature because…**
B00	2	(no reason given).
B01	10	(not able to code response given).
B10	12	nature already has its laws/rules. Scientists have to research/prove and explain them.
B20	13	scientists need to provide reasons for the behaviour of nature.
B21	2	scientists explore and learn more about the laws/theories.
B30	8	scientists perform experiments to prove the laws or theories/the behaviour of nature.
B31	4	research/experiments are used to explain/describe nature/a system.
B32	10	scientists experiment on what they observe and then formulate laws/theories on what will explain nature.
B33	-	experiments are used to predict phenomena.
B34	7	theories can change/improve with new information/as nature evolves.
B40	2	scientists help to improve the world/find solutions to problems.
B50	1	scientists model nature.
B51	-	scientists use mathematical model.
B52	16	the exact law is complex/cannot be obtained. A theory provides simpler explanation of what is observed in nature/from

		experiments.
B53	4	formulae/equations/mathematics/calculations are used.
B60	1	scientists use logic to explain nature.
B61	-	imagination and creativity are required.
B62	1	previous knowledge is also used.
B70	-	science is based on inventions.
B80	9	theories are simpler ways of putting together what scientists have gathered from experiments/nature/observations for better understanding.
C		**I have another view which I will explain.**
C00	-	(no reason given).
C01	2	(not able to code response given).
C10	6	Nature already has its laws/rules. Scientists have to research/prove and explain them.
C20	4	Scientists need to provide reasons for the behaviour of nature.
C30	6	Scientists perform experiments to prove the laws or theories/the behaviour of nature.
C31	1	Research/experiments are used to explain/describe nature/a system.
C32	1	Scientists experiment on what they observe and then formulate laws/theories on what will explain nature.
C33	-	Experiments are used to predict phenomena.
C34	1	Theories can change/improve with new information/as nature evolves.
C40	5	Scientists help to improve the world/find solutions to problems.
C50	1	Scientists model nature.
C52	1	The exact law is complex/cannot be obtained. A theory provides simpler explanation of what is observed in nature/from experiments.
C80	1	Theories are simpler ways of putting together what scientists have gathered from experiments/nature/observations for better understanding.
C90	9	Scientists discover the laws of nature and also construct theories.

3. You continue to think about science

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A		**New scientific knowledge is based on the results from scientific experiments because…**
A00	2	(no reason given).
A01	4	(not able to code response given).
A10	-	experiments are used to support/test a hypothesis.
A11	12	experiments are used to prove a hypothesis/phenomenon.
A12	-	experiments can be used to falsify/disprove a hypothesis.
A14	-	experiments provide evidence.
A20	26	results from experiments are reliable/accurate.
A21	-	results from experiments are most reliable to construct laws.
A22	2	results from experiments are most reliable to construct theories/theorems.
A23	11	results from experiments provide more knowledge/information about what we are investigating/how nature works.
A24	-	experiments help scientists to choose among competing theories.
A25	-	traditionally experiments have been used to provide information/ to construct scientific knowledge.
A30	-	experiments reveal the truth about nature.
A31	-	experiments do not involve inaccuracies/assumptions.
A32	-	scientific method is used to do experiments.
A33	-	it is a process carried out carefully in the laboratory.
A34	2	highly sophisticated/sensitive apparatus are used.
A35	-	it leads to the required result.
A40	-	experiments lead to improvements.
A41	-	experiments provide solutions to problems.
A42	5	experiments lead to new discovery.
A50	1	science is based on experiments.
A62	1	scientific theories are always being improved/refined with new information/evidence.
A73	1	existing scientific theories can be used to design scientific experiments.
B		**No, new scientific knowledge can result from existing scientific theories, because…**
B00	2	(no reason given).
B01	5	(not able to code response given).
B11	4	experiments are used to prove a hypothesis/phenomenon.
B12	-	experiments can be used to falsify/disprove a hypothesis.
B13	3	the existing scientific theories have already been proved to be correct from past experiments.
B20	1	results from experiments are reliable/accurate.

B23	1	results from experiments provide more knowledge/information about what we are investigating/how nature works.
B34	3	highly sophisticated/sensitive apparatus are used.
B60	3	scientific theories are subject to change with accumulation of new information/evidence.
B61	-	scientific theories change when existing information is viewed in a new perspective.
B62	11	scientific theories are always being improved/refined with new information/evidence.
B70	-	existing scientific theories have firm/well established information.
B71	1	existing scientific theories can explain/predict a wide range of phenomenon.
B72	5	existing scientific theories provide a framework for current knowledge/future investigations.
B73	-	existing scientific theories can be used to design scientific experiments.
C		**I have a different idea.**
C00	-	(no reason given).
C01	5	(not able to code response given).
C11	9	Experiments are used to prove a hypothesis/phenomenon.
C12	-	Experiments can be used to falsify/disprove a hypothesis.
C13	2	The existing scientific theories have already been proved to be correct from past experiments.
C20	6	Results from experiments are more reliable/accurate.
C21	-	Results from experiments are most reliable to construct laws.
C22	2	Results from experiments are most reliable to construct theories/theorems.
C23	2	Results from experiments provide more knowledge/information about what we are investigating/how nature works.
C34	3	Highly sophisticated/sensitive apparatus are used.
C71	1	Existing scientific theories can explain/predict a wide range of phenomenon.
C80	43	Both scientific experiments and scientific theories are required.
C90	-	Inference is also used.
C91	-	Scientists use their creativity and imagination.
C92	-	Logical thinking is required.
C93	-	Previous knowledge is also used.
C94	-	Scientists model nature.
C95	-	Scientists use mathematical model.
C96	-	Scientists use formulae/equations.

4. You and your friends now talk about scientific experiments

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A00	-	(no reason given).
A01	3	(not able to code response given).
A10	-	To reveal the exact cause/the truth about nature.
A11	15	To better explain/understand the behaviour of nature/ a theory.
A12	-	To model the laws of nature.
A20	60	To prove a hypothesis/phenomenon to be correct.
A21	-	To falsify/disprove a hypothesis.
A22	30	To prove whether a theory is correct or not.
A30	27	Results from experiments are more reliable/valid.
A31	1	Results from experiments are most reliable to construct laws.
A32	3	Results from experiments are most reliable to construct theories/theorems.
A33	20	Results from experiments provide more knowledge/information about what we are investigating/how nature works.
A34	-	Experiments help scientists to choose among competing theories.
A40	9	It leads to improvements/find solutions to problems.
A41	5	It leads to discoveries.
A50	3	Science is based on experiments.
A60	3	It helps to memorize scientific knowledge.

5. You continue to think about scientific measurement

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**Sometimes only one scientific measurement is sufficient for an exact result because…**
A00	p	-	(no reason given).
A01	p	3	(not able to code response given).
A10	s	-	it depends on how sensitive the instrument is.
A11	p	-	scientific measurement uses highly sophisticated apparatus.
A12	p	-	the sensitivity of a scale cannot be changed indefinitely.
A13	p	-	technology is improving all the time.
A14	p	1	it depends on the type of instrument used. (A Vernier calliper/micrometer screw gauge will always yield the same value).
A20	p	1	it depends on the type of measurements/experiments. (If it is voltage of a battery, repeating the measurement will give the same result).
A30	p	1	it is useless to take multiple reading when the value is already known (from theory)/if the measurement is done carefully.
A31	p	2	it is useless to repeat measurement if the experiment is done under the same/required conditions.
A32	p	1	repeating is a waste of time/resources.
A40	p	-	repeating measurements yield a value close to the true value/the required value.
A41	p	1	repeating the measurements will yield the same and correct result.
A50	-	-	a reference scale is used.
A61	s	1	average reduces/eliminates errors.
B			**No, for scientific measurement result to be exact, the experiment needs to be repeated many times and the average calculated because…**
B00	-	1	(no reason given).
B01	-	6	(not able to code response).
B20	p	1	it depends on the type of measurements/experiments. (If it is voltage of a battery, repeating the measurement will give the same result).
B30	p	1	it is useless to take multiple reading when the value is already known (from theory)/if the measurement is done carefully.
B40	p	-	repeating measurements yield a value close to the true value/the required value.
B41	p	14	repeating to see if the measurements are same and correct.
B42	p	2	repeating measurements to choose the recurrent value.

B43	p	1	repeating give the recurrent values which are then chosen to get an average.
B44	p	11	repeating to get values close to one another/to get a pattern.
B45	p	21	repeating to make sure of the value obtained.
B46	p	11	repeating to reduce/eliminate errors.
B47	p	20	repeating makes the result/value more accurate.
B48	p	3	repeating to get the right/true value.
B49	p	1	measurements must be repeated (no reasons provided)
B60	s	-	average reduces differences/uncertainties among readings.
B61	s	10	average reduces/eliminates errors.
B62	p	4	average gives a value close to the true/required value.
B63	s	2	average yields the best approximate.
B64	s	9	average gives a better value/more accurate value.
B65	s	-	average gives a value which lies within an interval.
B66	p	1	average yield the exact value.
B70	s	-	measurements taken under the same/different experimental/environmental conditions yields different readings.
B71	s	-	measurement involves judgement.
B72	s	4	experiments/measurements are affected by external factors/measuring process.
B73	s	1	variations in measurement occur.
B75	s	3	measurements/experiments/apparatus used always involve errors/inaccuracies.
C			**I have another idea.**
C00	-	-	(no reason given).
C01	-	-	(not able to code response).
C10	s	-	It depends on how sensitive the instrument is.
C11	p	-	Scientific measurement uses highly sophisticated apparatus.
C12	s	-	The sensitivity of a scale cannot be changed indefinitely.
C13	p	-	Technology is improving all the time.
C14	p	-	It depends on the type of instrument used. (A Vernier calliper/micrometer screw gauge will always yield the same value).
C20	p	5	It depends on the type of measurements/experiments. (If it is voltage of a battery, repeating the measurement will give the same result).
C31	p	1	It is useless to repeat measurement if the experiment is done under the same/required conditions.
C40	p	1	Repeating measurements yield a value close to the true value/the required value.
C41	p	5	Repeating to see if the measurements are same and correct.
C42	p	4	Repeating measurements to choose the recurrent value.
C43	p	1	Repeating give the recurrent values which are then chosen to get an average.
C45	p	2	Repeating to make sure of the value obtained.
C47	p	1	Repeating makes the result/value more accurate.
C60	s	-	Average reduces differences/uncertainties among readings.

C61	s	3	Average reduces/eliminate errors.
C62	p	3	Average gives a value close to the true value.
C63	s	1	Average yields the best approximate.
C64	s	2	Average gives a better value/more accurate value.
C70	s	1	Measurements taken under the same/different experimental/environmental conditions yields different readings.
C71	s	1	Measurement involves judgement.
C72	s	2	Measurements are affected by external factors.
C73	s	-	Variations in measurement occur.
C74	s	1	Only the best approximate can be obtained.
C75	s	1	Measurements/experiments/apparatus used always involve errors/inaccuracies.
C80	s	2	Repeating will give an accurate measurement with its uncertainty value.
C81	s	-	The uncertainty value can never be zero.

6. <u>You now think about whether or not there is a difference between scientific measurements and measurements made in everyday life</u>

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**<u>Both</u> scientific measurements and everyday measurements can be exact because…**
A00	-	-	(no reason given).
A01	-	4	(not able to code response given).
A10	p	7	the same/reliable/highly sophisticated apparatus is used.
A11	p	7	it depends on the quality/accuracy of the apparatus being used.
A12	p	3	scientific measurements deal with highly sophisticated/accurate instruments.
A20	p	-	both lead to reliable/true conclusions/values.
A21	p	-	both give the same/expected/required value.
A30	p	2	both give a value which is close to the true value.
A31	s	1	both give the best approximate.
A32	s	-	both give a value which lies within a range.
A40	s	2	both depend on the accuracy/judgement of the individual.
A50	p	3	in both cases, measurement must be repeated.
A51	s	-	in both cases, measurement must be repeated to get an average.
A52	p	-	in both cases, measurement must be repeated to get closer to the true value.
A53	p	-	in both cases, measurements are repeated and the recurrent value is selected.
A54	p	-	repeating the measurement will give the same value.
A60	p	2	both can be exact but scientific measurement is more precise/accurate than everyday measurement.
A61	s	-	both are inexact but scientific measurement is more precise/accurate than everyday measurement.
A70	-	1	it depends on the purpose of measurement whether or not it will affect the quantity or quality of the product obtained.
A71	-	3	it depends on how the process/measurement was carried out.
A80	-	4	science is everywhere.
A81	p	-	science is built on exactness.
A82	p	-	science yields the truth.
A84	p	2	in science, exact values are required as they are needed for further calculations/to be successful in a scientific endeavour.
A86	p	1	in both cases, we need to be successful.
A87	-	1	scientific measurement require a step by step process/scientific method.
B			**I think that scientific measurements can be exact, but everyday measurements are <u>never</u> exact because…**
B00	-	-	(no reason given).

B01	-	1	(not able to code response given).
B11	p	-	it depends on the quality/accuracy of the apparatus being used.
B12	p	9	scientific measurements deal with highly sophisticated/accurate instruments.
B13	p	-	scientific experiments use electronic device to get an exact answer.
B14	-	-	everyday measurements use an analogue scale.
B22	p	-	scientific measurement must yield better/exact results/the required value.
B33	p	2	scientific measurements give a value close to the true value.
B41	p	12	everyday measurements are rough estimates/depend on the judgement of the individual.
B55	p	3	in science, measurements must be repeated.
B56	s	-	scientific measurements are repeated to get an average.
B57	p	-	scientific measurements are repeated to get closer to the true value.
B58	p	-	scientific measurements are repeated and the recurrent value is chosen.
B60	p	-	both are exact but scientific measurement is more precise/accurate than everyday measurement.
B61	s	-	both are inexact but scientific measurement is more precise/accurate than everyday measurement.
B70	-	2	it depends on the purpose of measurement whether or not it will affect the quantity or quality of the product obtained.
B71	p	1	both can be exact depending on how the process/measurement was carried out.
B81	p	-	science is built on exactness.
B82	p	2	science yields the truth.
B83	-	-	scientific measurement is a process carried out in the laboratory.
B84	p	3	in science, exact values are required as they are needed for further calculations/to be successful in a scientific endeavour.
B85	-	-	scientific measurement makes use of a reference scale.
B87	-	-	scientific measurement require a step by step process/scientific method.
B90	s	-	scientific measurements always have an uncertainty value associated with it.
C			**No. Both scientific measurements and everyday measurements are <u>never</u> exact because…**
C00	-	1	(no reason given).
C01	-	4	(not able to code response given).
C11	p	-	it depends on the quality/accuracy of the apparatus being used.
C30	p	1	both give a value which is close to the true value.
C31	s	-	both give the best approximate.
C32	s	-	both give a value which lies within a range.
C40	s	2	both depend on the accuracy/judgement of the individual.
C41	p	2	everyday measurements are rough estimates/depend on the judgement of the individual.
C42	s	34	both involve inaccuracies/errors/assumptions.
C43	s	1	both are affected by external factors.
C44	s	1	variations have to occur.

C45	s	4	the instrument have limitations/inaccuracies.
C61	s	6	both are inexact but scientific measurement is more precise/accurate than everyday measurement.
C62	-	1	scientific measurement is more precise/accurate than everyday measurement.
C70	-	-	it depends on the purpose of measurement whether or not it will affect the quantity or quality of the product obtained.
C90	s	-	scientific measurements always have an uncertainty value associated with it.
C91	s	-	both have an uncertainty value associated.
D			**I have a different idea.**
D00	-	-	(no reason given).
D01	-	2	(not able to code response given).
D11	p	2	It depends on the quality/accuracy of the apparatus being used.
D12	p	3	Scientific measurements deal with highly sophisticated/accurate instruments.
D22	p	1	Scientific measurement must yield better/exact results/the required value.
D23	p	1	It depends if in both cases the same value is obtained.
D31	s	1	Both give the best approximate.
D33	p	1	Scientific measurements give a value close to the true value.
D34	s	-	Scientific measurement gives the best approximate.
D35	s	-	Scientific measurement gives a value which lies within a range.
D40	s	2	Both depend on the accuracy/judgement of the individual.
D41	p	2	Everyday measurements are rough estimates/depend on the judgement of the individual.
D42	s	4	Both involve inaccuracies/errors/assumptions.
D43	s	-	Both are affected by external factors.
D50	p	1	In both cases, measurement must be repeated.
D60	p	2	Both are exact but scientific measurement is more precise/accurate than everyday measurement.
D61	s	1	Both are inexact but scientific measurement is more precise/accurate than everyday measurement.
D62	-	3	Scientific measurement is more precise/accurate than everyday measurement.
D70	-	5	It depends on the purpose of measurement whether or not it will affect the quantity or quality of the product obtained.
D71	p	6	Both can be exact depending on how the process/measurement was carried out.
D72	p	2	Everyday measurements can be exact depending on how the process was carried out.
D73	p	1	Scientific measurements can be exact depending on how the process was carried out.
D82	p	2	Science yields the truth.
D84	p	2	In science, exact values are required as they are needed for further calculations/to be successful in a scientific endeavour.
D87	p	1	Both need to follow the given instructions.
D88	-	1	An exact measurement can never be obtained.

7. The scientists are discussing what they should do in their experiment

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A		**I think that scientists always strictly follow the "Scientific Method" which prescribes a sequence for carrying out an experiment because…**
A00	-	(no reason given).
A01	2	(not able to code response given).
A10	-	"Scientific method" is a traditional way of "doing" science.
A11	1	"Scientific method" has been proved to always yield trustworthy and logical results.
A20	3	science involves laws and procedures which need to be followed.
A21	3	it is the best/accurate method.
A30	-	science is complex. We use "Scientific method" to obtain reliable results/knowledge.
A40	1	we need to have values close to one another.
A41	32	we need to be successful in our experiment/have consistency in our results/get reliable and accurate knowledge.
A42	6	we need to get the expected/required value.
A50	1	scientists use their creativity only when planning the experiment but use the "Scientific method" to do the experiment.
A51	-	scientists use their creativity only when interpreting their results/ formulating a conclusion.
A90	1	the use of creativity can lead to further discovery.
A92	-	scientists use scientific method to improve their experiment/results.
A93	-	scientific method lead to further discovery.
B		**No, I think that scientists <u>also</u> use their creativity when carrying out an experiment because…**
B00	-	(no reason given).
B01	10	(not able to code response given).
B20	1	science involves laws and procedures which need to be followed.
B40	-	we need to have values close to one another.
B41	12	we need to be successful in our experiment/have consistency in our results/get reliable and accurate knowledge.
B42	3	we need to get the expected/required value.
B50	2	scientists use their creativity only when planning the experiment but use the "Scientific method" to do the experiment.
B51	3	scientists use their creativity only when interpreting their results/ formulating a conclusion.
B52	6	of unexpected problems while doing the experiment.
B54	2	the scientific method can be faulty.
B55	1	experiments involve the use of logic.
B56	1	creativity is required to have new knowledge.

B60	12	depending on the type of experiments scientists design and develop their own procedure which is most suitable for them to do the experiment.
B70	-	“Scientific method” is a way of reporting a research/experiment such that knowledge is meaningful and accessible to everyone.
B80	3	scientists also use previous knowledge/theories when doing an experiment.
B90	48	the use of creativity can lead to further discovery.
B91	23	scientists use creativity for improvements.
B94	1	the use of imagination and creativity help to solve problems.

8. **<u>The scientists now start taking measurements. They first use a very sensitive instrument with a digital scale to measure the Earth's magnetic field</u>**

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**I think that the scientists now know that the Earth's magnetic field is <u>exactly</u> 0.137 mT because…**
A00	p	-	(no reason given).
A01	p	1	(not able to code response given).
A10	p	14	a sensitive digital metre is used.
A11	p	-	the instrument is at its maximum sensitivity.
A12	p	1	the scale shows 3 digits after the decimal.
A16	-	2	it is what is shown by the instrument.
A20	p	-	a digital metre does not require judgement when taking a reading.
A21	p	-	measurements always yield an exact number.
A22	p	-	science needs exact value which will be used to perform further calculations.
A30	p	-	repeating the experiment will yield different value.
A34	p	1	repeating the measurement to see if the same value is obtained.
B			**I think that the scientists only have an <u>approximate</u> value of the Earth's magnetic field because…**
B00	-	1	(no reason given).
B01	-	2	(not able to code response given).
B10	p	2	a sensitive digital metre is used.
B13	s	2	changing the sensitivity of the digital metre will give more accurate value.
B14	s	-	use of different instruments will give different values.
B15	s	10	it depends on how accurate the instrument is.
B23	p	-	science is exact but measurement is inexact and hence use "approximate".
B24	-	3	in science, only an approximation can be obtained.
B30	p	2	repeating the experiment will yield different value.
B31	p	25	measurement must be repeated many times/they have only 1 reading.
B32	p	-	many measurements need to be taken and the recurrent value selected.
B33	s	4	many measurements must be taken and get an average.
B34	p	3	repeating measurements to see if the same results are obtained.
B35	p	1	repeating will give values which are close to one another.
B36	p	-	many measurements must be taken to obtain an exact value.
B37	s	2	it is only the average value.
B38	-	-	the experiment must be repeated with different instrument to be more accurate.
B40	s	13	the value has been rounded off.

B50	s	11	measurements involve inaccuracies/errors.
B51	-	2	the apparatus is created by humans/may be faulty.
B52	s	27	experiments/measurements are affected by external factors/measuring process.
B53	s	1	judgement/estimation is required.
B54	s	11	there are some degree of inaccuracy in the apparatus.
B60	p	4	measurements always yield values close to the true value.
B61	p	-	only values close to one another can be obtained.
B70	s	-	measurements always yield the best estimate.
B71	s	1	the value of the magnetic field lies within a range.
B72	s	1	the scientists have the most accurate value.
B80	s	1	a reading has an uncertainty value associated with it is meaningless.
C			**I don't agree with either of you because…**
C00	-	-	(no reason given).
C01	-	2	(not able to code response given).
C10	p	2	a sensitive digital metre is used.
C13	s	-	the sensitivity of the digital metre can be changed to give more accurate value.
C14	s	-	use of different instruments will give different values.
C15	s	-	it depends on the accuracy of the instrument.
C20	p	-	a digital metre does not require judgement when taking a reading.
C31	p	8	measurement must be repeated many times/they have only 1 reading.
C32	p	1	many measurements need to be taken and the recurrent value selected.
C33	s	5	many measurements must be take and get an average.
C34	p	2	repeating measurements to see if the same results are obtained.
C35	p	-	repeating will give values which are close to one another.
C36	p	-	many measurements must be taken to obtain an exact value.
C38	-	-	the experiment must be repeated with different instrument.
C50	s	-	measurements involve inaccuracies/errors.
C51	-	-	the apparatus is created by humans/may be faulty.
C52	s	6	experiments/measurements are affected by external/measuring process.
C53	s	1	judgement/estimation is required.
C60	p	-	measurements always yield values close to the true value.
C62	p	2	it is a value closed to the true/exact value.
C70	s	-	measurements always yield the best estimate.
C72	s	1	the scientists have the most accurate value.
C80	s	-	a reading without an uncertainty value associated with it is meaningless.

9. <u>The scientists also need to know the temperature in the room in order to calibrate their results. They use a special thermometer</u>

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**The temperature is <u>exact</u> because…**
A00	p	1	(no reason given).
A01	p	7	(not able to code response given).
A10	p	24	this is what is shown by the analogue scale.
A11	p	2	the analogue thermometer is very sensitive.
A20	p	-	science is built on exactness.
A21	-	-	scientific method was used to carry out the experiment.
A22	p	-	repeating the experiment under the same conditions will yield the same result.
A30	p	68	the needle is on the 24 degree mark.
A31	s	2	the value for temperature lies within an interval.
A32	-	10	it is the ideal temperature required for a laboratory/to carry out an experiment.
A41	p	4	it is a value close to the room temperature/the required value.
A42	p	1	it should not exceed the room temperature.
A43	p	3	it is a value less than the room temperature.
A44	p	2	it is the room temperature of the laboratory.
A60	s	4	experiments/measurements are affected by external/measuring process.
A61	s	1	there are many errors/inaccuracies associated with measurement.
A80	p	1	measurements must be repeated (no reason provided).
B			**The temperature is <u>approximate</u> because…**
B00	s	-	(no reason given).
B01	s	3	(not able to code response).
B12	s	6	it depends on the accuracy of the thermometer.
B13	-	4	analogue scale/thermometer needs to be divided into more divisions.
B14	-	-	more calibrations will reduce uncertainty.
B15	s	3	more calibrations will lead to more accurate reading.
B16	p	-	more calibrations will yield the exact value.
B23	p	-	science is exact but measurement is inexact and hence use “approximate”.
B24	s	-	an exact reading cannot be obtained. We just have the best estimate.
B25	-	-	in science, an “exact” value/result does not exist.
B26	p	-	an exact temperature can only be obtained by using a digital scale.
B30	-	2	the needle is on the 24 degree mark.
B31	s	-	the value for temperature lies within an interval.
B40	p	-	measurement is about yielding a value close to the true value.

B41	p	-	it is a value close to the room temperature/the required value.
B50	s	-	an average will give a better/more accurate value.
B60	s	18	experiments/measurements are affected by external/measuring process.
B61	s	7	there are many errors/inaccuracies associated with measurement.
B62	s	1	use of analogue scale is never accurate.
B63	s	2	the value has been rounded off.
B70	p	-	temperature should be measured using a different thermometer and results compared.
B80	p	-	measurements must be repeated (no reason provided).
B81	p	-	many measurements must be taken and the most recurrent value chosen.
B90	s	1	a measurement result has an uncertainty value associated with it.
B91	s	-	the uncertainty cannot be reduced to zero.
C			**The temperature lies within an <u>interval/a range</u> of temperature because….**
C00	s	-	(no reason given).
C01	s	1	(not able to code response).
C12	s	-	it depends on the accuracy of the thermometer.
C13	-	-	analogue scale/thermometer needs to be divided into more divisions.
C14	-	-	more calibrations will reduce uncertainty.
C15	s	-	more calibrations will lead to more precise/accurate reading.
C16	p	-	more calibrations will yield the exact value.
C25	-	-	in science, an “exact” value/result does not exist.
C30	-	-	the needle is on the 24 degree mark.
C31	s	-	the value for temperature lies within an interval.
C32	-	-	it is the ideal temperature required for a laboratory.
C40	p	-	measurement is about yielding a value close to the true value.
C41	p	1	it is a value close to the room temperature/the required value.
C50	s	-	an average will give a better/more accurate value.
C60	s	-	experiments/measurements are affected by external/measuring process.
C61	s	-	there are many errors/inaccuracies associated with measurements.
C90	s	-	a measurement has an uncertainty value associated with it.
C91	s	-	the uncertainty cannot be reduced to zero.

10. <u>The scientists discuss whether or not they should repeat their measurement of the magnetic field</u>

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**I think that the scientists should repeat their measurement of the magnetic field <u>a few times</u> because…**
A00	-	-	(no reason given).
A01	-	-	(not able to code response).
A10	p	1	repeating for practice.
A11	p	-	practice will produce more accurate or better measurement.
A12	p	-	practice will reduce the systematic error in measurement.
A20	p	10	repeating gives readings which are close together/to get a pattern.
A21	p	22	repeating to be sure/confirm the results.
A22	p	6	repeating to get an exact/required value.
A23	p	11	repeating reduces/eliminates errors.
A24	p	31	repeating gives a more accurate/better measurement.
A25	p	3	repeating to get closer to the true value.
A30	s	21	more readings needed to get an average.
A31	s	9	to get a more accurate/reliable average.
A32	s	-	to get an average and a spread/uncertainty.
A33	s	-	to get an average and a better/narrower spread/uncertainty.
A34	p	4	to get an average in order to get closer to the true value.
A35	s	3	to get an average which reduce errors.
A36	p	1	the values which are close to one another must be selected to calculate the average value.
A40	p	29	repeating may give the same and correct answer.
A50	p	1	to get a variety of results.
A60	p	5	repetition is necessary (no reason provided).
A61	s	-	you must always get three measurements.
A70	s	1	the spread/uncertainty must be determined.
A71	p	-	a better/narrower spread/uncertainty must be determined.
A72	s	-	the uncertainty must be determined to get closer to the true value.
A80	s	2	experiment/measurements are affected by external/measuring process.
B			**Why? They have their result already. They do not need to repeat the measurement because…**
B00	-	-	(no reason given).
B01	p	-	(not able to code response).
B40	p	-	repeating may give the same and correct answer.
B51	p	1	repeating is a waste of time/resources.
B53	p	-	repeating will give different results which is confusing/faulty.

C			**I think that the scientists should repeat their measurement <u>one more time</u> because…**
C00	-	-	(no reason given).
C01	-	1	(not able to code response).
C11	p	-	practice will produce more accurate or better measurement.
C12	p	-	practice will reduce the systematic error in measurement.
C20	p	1	repeating gives readings which are close together.
C24	p	3	repeating gives a more accurate/better measurement.
C30	s	-	more readings needed to get an average.
C31	s	-	to get a more accurate/reliable average.
C40	p	9	repeating may give the same and correct answer.
C50	p	-	to get a variety of results.
C51	p	3	repeating is a waste of time/resources.
C52	p	-	many repeats are desirable, but time consuming.
C90	p	-	the value will keep on changing.

11. The scientists decide to repeat their measurement of the magnetic field five times

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**0.128 mT.**
A00	-	-	(no reason given).
A01	-	1	(not able to code response).
A10	p	41	It appears twice in the set of values.
A20	p	-	It is the exact value.
A30	s	-	It is the average value.
A40	p	-	It is closest to the average value.
A50	s	-	It is the median value.
A91	-	1	It is the minimum value.
B			**0.133 mT.**
B00	-	-	(no reason given).
B01	-	-	(not able to code response).
B30	s	82	It is the average value.
B31	p	3	The value obtained by excluding the highest and lowest value.
B40	p	-	It is closest to the average value.
B41	p	1	It is close to 0.128 mT which occur twice.
B42	p	-	It is closed to the last value (0.134 mT) obtained after much practice.
B43	p	-	It is the best estimate.
B50	s	1	It is the median value.
C			**0.134 mT.**
C00	-	-	(no reason given).
C01	-	-	(not able to code response).
C30	s	9	It is the average value.
C40	p	5	It is closest to the average value.
C41	p	2	It is close to the other values.
C50	s	-	It is the median value.
C60	p	1	It is the last measurement and hence more accurate as it has been obtained after practising five times.
C80	p	3	It is the middle measurement.
D			**0.137 mT.**
D00	-	-	(no reason given).
D01	-	-	(not able to code response).
D30	s	1	It is the average value.
D40	p	-	It is closest to the average value.
D43	p	1	It is close to the third value obtained (0.138 mT).
D50	s	-	It is the median value.
D61	p	-	It is the first measurement obtained for the magnetic field and hence more accurate.

E			**0.138 mT.**
E00	-	-	(no reason given).
E01	-	-	(not able to code response).
E30	s	1	It is the average value.
E40	p	-	It is closest to the average value.
E44	p	-	It is close to the first value obtained (0.137 mT)**.**
E50	s	-	It is the median value.
E90	p	1	It is the highest value.
F			**Other**
F00	-	-	(no reason given).
F01	-	-	(not able to code response).
F11	p	3	The recurrent value must be chosen.
F45	p	3	Choose a value which is close to the remaining values/one another.
F70	s	8	Calculate the average.
F71	p	3	Choose the values which are close to one another and calculate the average.
F72	-	-	Calculate the sum of all five measurements.
F73		1	Take a range of values.
F81	p	1	It is the middle value.

12. <u>The scientists now decide to compare their results with the results from an experiment on magnetic fields completed by another group of scientists</u>

N00 - No response
U00 - Not able to code response

		Frequency of codes	
A			**The results of groups A and B <u>agree</u> with each other because…**
A00	-	-	(no reason given).
A01	-	-	(not able to code response given).
A10	p	56	the average value for both groups are more or less the same.
A11	p	9	the average value for both groups are more or less the same, the difference is due to external (environmental/experimental) factors.
A12	p	-	the average value for both groups are more or less the same, both being close to the true value of the magnetic field.
A13	p	6	the average value for both groups are close to each other and in any experiment a difference will always exist.
A14	p	20	the average values are more or less the same, the small difference is negligible.
A15	p	13	on rounding off, the averages are more or less the same/the same values are obtained.
A20	p	5	the readings/measurements for both sets are more or less the same.
A21	p	3	the readings/measurements for both sets have the same spread.
A22	s	1	the readings/measurements have an overlapping spread.
A23	p	-	group A readings are much closer to one another.
A24	p	10	some/most measurements of group A repeat themselves in group B.
A28	p	1	the recurrent measurement/reading should be selected.
A30	s	1	the uncertainties of the averages may overlap.
A31	s	1	the averages are more or less the same with similar ranges/spreads.
A32	p	-	the uncertainties for both groups are close to each other.
A33	s	-	the uncertainties for both group overlap.
A44	p	2	the average lies between the range of measurement obtained in group A and group B.
B			**No, the results <u>do not agree</u> with each other because…**
B00	-	-	(no reason given).
B01	-	4	(not able to code response given).
B10	p	2	the average value for both groups are more or less the same.
B22	s	1	the spread for both set of measurements is different.
B23	s	-	the spread for both averages is different.
B25	p	1	only two of the readings repeat themselves in both groups.
B26	p	14	the measurement/reading is different.
B27	p	-	the average is different and only 2 of the readings repeat themselves in both group.
B34	s	-	the uncertainties do not overlap.
B35	s	-	the uncertainties for both set of measurement need to be calculated to know whether they overlap.

B40	p	16	the average is different in both cases.
B41	p	1	the average is different as the experiment is affected by external (experimental/environmental).
B42	p	-	the average is different and the true/exact value cannot be known.
B43	p	7	for the two groups to agree, the average should be the same in both cases.
B50	p	-	the two groups will only agree if the average value obtained in each case appears as one of the measurement.
B60	p	3	absolute accuracy/identical results are required to agree.

13. <u>The scientists find that the result from their experiment does not agree with the value predicted by their theory</u>

N00 - No response
U00 - Not able to code response

	Frequency of codes	
A		**I think that the scientists might now have to revise their theory because…**
A00	-	(no reason given).
A01	8	(not able to code response given).
A10	15	results from experiments are more reliable/accurate.
A11	-	results from experiments are more reliable to construct a theory.
A12	37	the value predicted by theory may be faulty/inaccurate.
A13	1	experiments reveal the truth about nature/give the true value.
A14	-	scientific method was used to carry out the experiment.
A15	-	scientific experiments make use of highly accurate instrument.
A20	10	theory is based on experiments which prove whether it is right or wrong.
A21	5	the experiment has proved that the theory is wrong.
A30	5	theories are always being improved/refined with new evidence/information.
A31	2	theories are subject to change with the accumulation of new information.
A40	1	the experiment must be repeated.
A41	2	the theory must be changed if on repeating the experiment (after checking the theory using different/improved conditions/apparatus), the result obtained does not match theory.
A42	1	on repeating the experiment, both values must match.
A44	2	the experiment must be repeated after revising the theory.
A50	1	theory can never change. It has been proved by earlier experiments.
A60	1	experiments/measurements have approximations/inaccuracies.
A90	2	check both the theory and experiment.
A92	1	if on checking the experiment, no fault is found.
B		**No, the scientists should reject the value obtained from their experiment because…**
B00	-	(no reason given).
B01	-	(not able to code response given).
B23	-	the theory must be proved by the experiment.
B41	1	the theory must be changed if on repeating the experiment (after checking the theory using different/improved conditions/apparatus), the result obtained does not match theory.
B50	1	theory can never change. It has been proved by earlier experiments.
B60	-	experiments/measurements have approximations/inaccuracies.

B61	1	experiments/measurements are affected by external factors(environmental/experimental factors).
B62	-	measurements/experiments depend on the sensitivity of the apparatus.
B63	-	measurements/experiments depend on the judgement of scientists.
B70	-	new scientific knowledge can originate from scientific theories only.
B71	-	previous knowledge in this field has been used to construct the theory.
B72	-	the theory has a greater explanatory power than the experiment.
C		**I have another idea about what they should do.**
C00	-	(no reason given).
C01	6	(not able to code response given).
C10	3	Results from experiments are more reliable/accurate.
C12	6	The value predicted by theory may be faulty/inaccurate.
C13	-	The theory must be revised as value from experiment is more accurate/reliable.
C21	-	The experiment has proved that the theory is wrong.
C30	1	Theories are always being improved/refined with new evidence/information.
C31	-	Theories are subject to change with the accumulation of new information.
C40	9	The experiment must be repeated.
C41	15	The theory must be changed if on repeating the experiment (after checking the theory using different/improved conditions/apparatus), the result obtained does not match theory.
C43	3	Repeat the experiment as it involves errors.
C44	2	Repeat the experiment after revising the theory.
C50	2	Theory can never change. It has been proved by earlier experiments.
C60	1	Experiments/measurements have approximations/inaccuracies.
C61	1	Experiments/measurements are affected by external factors(environmental/experimental factors).
C62	-	Measurements/experiments depend on the sensitivity of the apparatus.
C63	-	Measurements/experiments depend on the judgement of scientists.
C70	-	New scientific knowledge can originate from scientific theories only.
C71	-	Previous knowledge in this field has been used to construct the theory.
C80	2	The two values do not have to match.
C81	4	The two values must be the same.
C90	25	Check both the theory and experiment.

14. <u>Finally, you think about how scientists may improve their measurement</u>

N00 - No response
U00 – Not able to code response

		Frequency of codes	
A			**With enough money and the best equipment, the scientists can design an experiment that would give them the <u>true value</u> of the magnetic field because…**
A00	-	-	(no reason given).
A01	-	21	(not able to code response given).
A10	p	7	the experiment can be refined.
A11	p	2	then the experiment will be successful.
A12	s	10	more accurate results/the correct value can be obtained.
A14	p	1	on repeating the same answer will be obtained.
A20	p	6	only then the exact/required value can be obtained.
A21	p	2	a value closer to the true value can be obtained.
A30	p	30	technology is improving all the time.
A61	p	-	then the reading will have zero uncertainty.
B			**That's not true! I think that the scientists will <u>never</u> know the true value of the magnetic field, no matter what they do because…**
B00	-	-	(no reason given).
B01	-	3	(not able to code response given).
B12	s	13	more accurate results/the correct value can be obtained.
B13	s	9	only the best approximate/best estimate can obtained.
B21	p	18	a value closer to the true value can be obtained.
B23	-	3	in physics/science the true result/value cannot be known.
B30	p	1	technology is improving all the time.
B40	p	14	you don't know whether you obtained the true value as you cannot control outside factors.
B41	s	2	there will always be deviation in the results obtained.
B42	s	5	human error or mistakes cannot be avoided.
B43	s	11	measurements/experiments are affected by external/measuring process.
B44	s	14	measurement/apparatus/experiments involve inaccuracies/errors.
B50	s	-	measurement is always quoted as a range/interval.
B60	s	1	it is impossible to get a reading with zero uncertainty.
B70	-	3	science/nature is complex.