

The following three questions (Q1-Q3) refer to the fictional prose below.

Seated behind his desk, Master Devon's thoughts were interrupted by a tentative knock on his office door. Thinking it was Dr Vorce, he was irritated and snapped, "Yes. What is it?"

From behind the door a small voice replied, "It's me, Apprentice Kell, Master Devon. I need help with the beginner spell you showed us last week."

Softening, Devon sighed, "OK. Come on in."

As Kell entered the office closing the door behind him. Devon frowned and said, "You know it's a bit late to be coming to see me about this now, don't you?"

"Yes sir, I know, but I've been trying all week, practicing and reading, but no matter what I do I just can't get it to work."

Gesturing to Kell to come closer Devon sighed again, "Show me then".

As Kell launched into a short series of hand gestures ending with a soft blowing of air into his right palm he stared at Master Devon and said "See sir, nothing. I've repeated it hundreds of times, and nothing happens every time. I'm doing it just the way you taught us, but..." Kell's shoulder's slumped and he dropped his gaze to the floor.

Devon got up from behind his desk and approached the young man. "Apprentice Kell. If you are doing it exactly the same each time, and it didn't work the first time, what makes you think it would work a second, tenth, hundredth or even a thousandth time?" Kell responded, "Well, maybe I wasn't doing it right."

Devon grimaced, "But did you do anything different each time? Hmm?"

"Yes." Kell answered. When Kell added nothing further, Devon become irritated and asked, "What then? Speak up!"

"Well, I tried harder." Kell responded sheepishly.

Devon rolled his eyes and placed a hand on Kell's shoulder, "Kell, you need to think lad. If you wish to be a mage this type of thinking won't get you there. If it didn't work the first time, then you need to think about *why* it didn't work, not just simply repeat what doesn't work without any thought. You need to come up with an explanation of why it didn't work, then check and see if that's the reason, if not then you must think of some other reason for why it's not working. Do you understand what I'm saying to you?"

Kell looked up at Devon, his vision a little blurry with restrained tears, "But Master Devon, what if it's just me?"

Devon laughed. "Don't be ridiculous lad. Nothing in this world works..."

Just then the door to Master Devon's office burst open and none other than the scientist Dr Vorce entered loudly saying. "Devon you're needed immediately... Oh, you're with Kell, sorry I didn't mean to interrupt."

Angry, Devon responded, "Well you did interrupt Vorce, and as always you're a particularly rude fellow. Next time knock, now leave and I'll drop by when I'm done assisting young Kell here with his studies."

Unperturbed by Devon's chiding, Dr Vorce offered, "Oh, perhaps I can be of assistance to Apprentice Kell?"

Devon immediately responded, "No. You cannot. Leave Vorce! This isn't science; it's magic. All your physics, chemistry and biology is useless here. Butt out and stick to what you know!"

Question 1

What are the two most obvious mistakes do Master Devon make when referring to Science in his brief exchange with Dr Vorce?

- a) **Science is defined by knowledge in certain specific disciplines.**
- b) **Scientific investigation can only be applied to certain subject areas.**
- c) Science can be applied to anything that has an observable and tangible effect in the world.
- d) Science involves making careful observations, providing an explanation for those observations then testing the explanation.
- e) Science is self-correcting.

Answers: a, b

Question 2

Consider Master Devon's statement "If you are doing it exactly the same each time, and it didn't work the first time, what makes you think it would work a second, tenth, hundredth or even a thousandth time?" What fundamental principle of science does this rely on?

- a) **Principle of reproducibility**
- b) **Principle of replicability**
- c) Principle of reversibility
- d) Principle of reciprocity
- e) Principle of reinforcement

Answers: a, b

Question 3

Immediately after Master Devon rolled his eyes and placed his hand on Apprentice Kell's shoulder he provided some advice on solving a puzzle. This advice is...

- a) **...the scientific method in a nutshell.**
- b) **...how you go about troubleshooting anything.**
- c) ...a clever manipulation of the student to ensure he fails his task.
- d) ...a twisted and inaccurate description of the scientific method in a nutshell.
- e) ...a paraphrase of the five concerns that must be addressed when making proper scientific observations.

Answers: a, b

The following 3 (Q4-Q6) questions refer to the claim:

“Drinking ice-cold water damages the spleen and stomach.”

Question 4

Select the steps below that should be taken in order to test this claim scientifically using a clinical trial.

- a) **Conduct a randomized controlled trial (a double-blind trial is not possible in this instance).**
- b) **Ensure that there are enough subjects involved in the trial, e.g., 500+, but preferably more.**
- c) **Ensure that all subjects are healthy and living healthy lives before and during the trial, also checking on the health of both the stomach and spleen before and after the trial.**
- d) Check the incidence of spleen and stomach damage in Eskimos who generally only ever drink ice-cold water and compare it to those of other world populations where drinking ice-cold water is rare or uncommon.
- e) All experimenters need to be fully qualified clinical doctors.

Answers: a, b, c

Question 5

Why is it not possible to conduct a double-blind trial in this instance?

- a) **It is not possible for a subject to be unaware of whether they are drinking ice- cold or room-temperature water.**
- b) It is not possible for the experimenters to be unaware of whether they are serving the subjects ice-cold or room-temperature water.
- c) It is not possible to either prepare or drink ice-cold or room-temperature while blinded.
- d) Because everyone is biased essentially randomly either for or against drinking ice-cold or room-temperature water.
- e) Because the placebo effect makes a double-blind trial in this instance impossible.

Answers: a

Question 6

While the trial cannot be double-blind, what could be done to ensure the next best thing?

- a) **Ensure that the subjects have no issues or beliefs associated with drinking either ice-cold or room-temperature water.**
- b) **Ensure that the experimenters have no issues or beliefs associated with drinking either ice-cold or room-temperature water.**
- c) **Ensure that the container in which the water is served in is darkened and covered and thermally insulated so no one can tell what's inside or if the container is cold.**
- d) Regardless of what is served to the subjects, randomly tell them it is either ice- cold or room-temperature water before serving it to them.
- e) Experimenters hand the water in a regular glass to the subjects but in a pitch- black room so neither experimenter nor subject can see the water being served.

Answers: a, b, c

The following 2 (Q7-Q8) questions refer to the information below:

A randomised controlled double-blind trial was conducted to see if NUS students could tell whether they had been given expensive coffee to drink. 25 students were given regular coffee to drink and 25 given the much more expensive coffee. 9 of the students given the regular coffee thought it was the expensive coffee, but 15 of the students given expensive coffee correctly said it was expensive coffee.

Note that here the control group is the 25 students given regular coffee, and the experimental group and those given expensive coffee.

Question 7

The margin of error for these two groups at the 95% confidence level is \pm BLANK1 %. The range of percentage points covered by the two CIs is BLANK2 %. The number of percentage points of overlap of the two CIs is BLANK3 %. (**NB** make sure your answer is a pure number, i.e., **DO NOT** a “%” sign)

BLANK1: answer is 22, so anything between 21 and 23 (inclusive) is OK.

BLANK2: answer is 68, so anything between 67 and 69 (inclusive) is OK.

BLANK3: answer is 20, so anything between 19 and 21 (inclusive) is OK.

Question 8

Can we be 95% confident that NUS students can tell whether they are drinking expensive coffee and why?

- a) Yes, because there's no overlap in the confidence intervals.
- b) Probably yes because the overlap in the confidence intervals is less than one-third of the range covered by the two CIs.**
- c) Probably no because the overlap in the confidence intervals is more than one-third of the range covered by the two CIs.
- d) No, because there is a very great amount of overlap between the two confidence intervals.
- e) Probably no because there is overlap in the confidence intervals.

Answer: b

The following 3 (Q9-Q11) questions refer to the information below:

A social science student decided to embark on a scientific investigation of how education level impacts wealth. Following the scientific method, she first decided to check the available literature, to see what, if any, evidence was available. She decided that income was a good starting point to measure wealth and hypothesized that the higher the level of education, the greater the income. Note that at this stage she had no explanation for this prediction, but just “felt” it should be so. She found the following data from the US Bureau of Labor Statistics for 2020. She wondered if the same trend held for Singapore.



Question 9

Classify the correlation illustrated in the graph. Indicate its strength and type.

- a) **Quite Strong.**
- b) Very Weak.
- c) Little to no correlation at all.
- d) **Positive correlation.**
- e) Negative correlation.

Answer: a, d

Question 10

Is there a causal link between median monthly earnings and education level?

- a) Yes, clearly. A higher level of education causes you to get a higher pay.
- b) **No. The explanation isn't cause and effect. A better strategy is to use a functional explanation.**
- c) Yes, clearly. A higher pay causes you to have a higher level of education.
- d) Yes, clearly, although figuring out the causal mechanism to go from the cause, “education level”, to the remote effect of, “medium salary” is illusive at this time, so requires further investigation.
- e) No. Correlation doesn't imply causation, therefore there can be no cause and effect here.

Answer: b

Comment: The BEST explanation is functional, i.e., an education serves the function of providing appropriate training so that higher paying jobs requiring higher levels of education and training can be applied for and obtained.

Question 11

Apparently, her “hunch” is supported by the evidence, but she now needs an explanation for the observed relationship, and for that explanation to have any weight, it needs to be tested. Select those options below that could be used in testing an explanation for the observed relationship.

- a) It is not possible to test explanations for such phenomena.
- b) Data showing a relationship between education level and the amount of knowledge and skills possessed, then data showing a relationship between higher paying jobs and knowledge and skills required.**
- c) Data showing a relationship in job advertisements between salary package and education level.**
- d) Data collected from a few employees of their personal views of the relationship between salary and education level.
- e) Data showing a relationship between education level and the number of connections possessed in LinkedIn.

Answers: b, c

The following two questions (Q12-Q13) refer to the observations and explanation given below.

The prices of face masks before the pandemic were low, but when it became compulsory to wear them the price quickly rose. It wasn't long before more face masks were produced, and the prices of face masks dropped again.

Now consider an explanation:

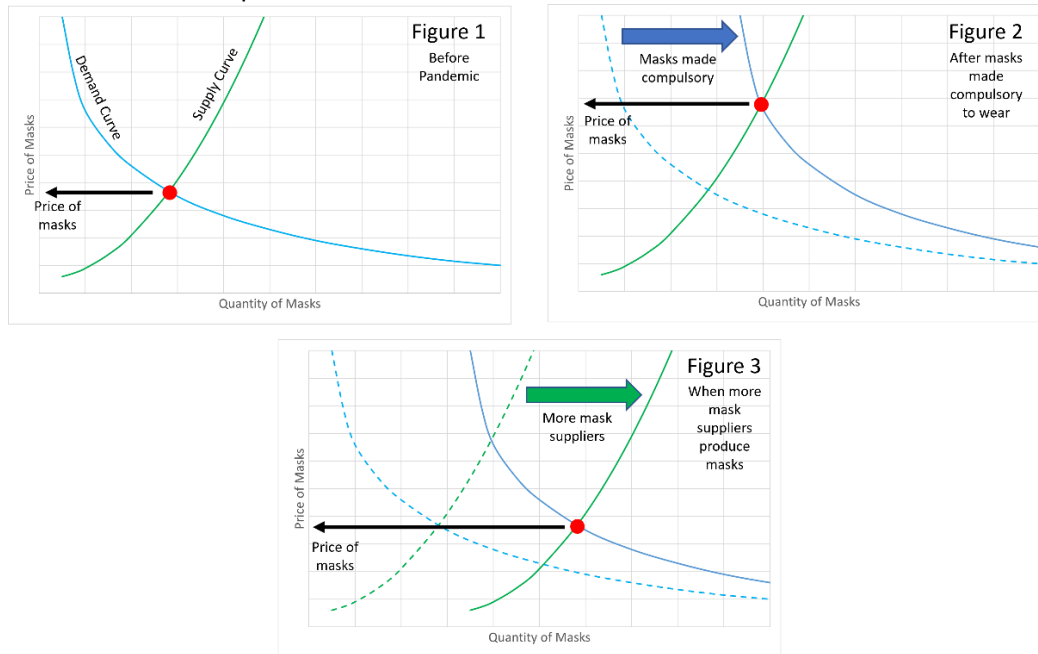


Figure 1 shows the situation before the pandemic. On the y-axis is the price per mask and along x-axis is the number of masks sold per week. The red dot represents the price of a mask before the pandemic along with the number sold per week. It is at the intersection of the demand curve (blue), which generally always slopes downwards, and supply curve (green) which generally always slopes upwards.

Figure 2 is the situation when mask wearing became compulsory. Suddenly everyone demanded masks, so the demand curve shifted to the right, and the new intersection of the supply and demand curves is a much higher price, with much more masks sold per week as observed.

Figure 3 is the situation when more mask suppliers came on-line. This time the supply curve shifts to the right and the price point falls with even more masks being sold per week.

Question 12

The statements that the demand curve generally always slopes downwards and the supply curve generally always slopes upwards is critical to this explanation of the price movement. What types of explanatory strategy is being invoked with these statements?

- a) Cause and effect
- b) Causal mechanism
- c) Underlying process
- d) Laws**
- e) Function

Answer: d

Question 13

Fill in only “A”, “B” or “C” in the blanks below. A, B and C mean the following:

A=physical model

B=conceptual model

C=math/computer model

(i) This qualitative explanation utilises what type of model? BLANK1

(ii) If you wanted to make a quantitative prediction of the price of mask when they were no longer compulsory to wear and assuming the number of suppliers didn’t change, which type of model would you need to employ? BLANK2

Answers: BLANK1 = B, BLANK2 = C

The following three questions (Q14-Q16) refer to the following:

Consider the following extract from a web site selling magnetic bracelets and copper bracelets. They claim magnetic bracelets help with arthritis pain, rheumatism, carpal tunnel syndrome, football and tennis injuries, period pain, RSI, poor circulation, migraine headaches, muscle soreness, and a long list of joint pain.

How does Magnetism work and what are the benefits

One of the theories about how magnetism works with the body is that the fields surrounding the magnetic bracelets stimulate the field where the pain occurs. This is thought to trigger the release of the body's own painkillers, thereby providing natural relief for the person instead of having to take medications over long periods that may have bad side-effects.

It is also thought that because metals like iron, zinc and magnesium are essentially components already found in the human body. Magnetism is able to affect them in a way that brings about helpful change at the cellular level; particularly by impacting on particles in the blood and increasing oxygenation so that circulation is improved, and a person heals quicker. After all, everyone knows what happens when you put a magnet beside a metal: it attracts it.

The website continues with various testimonials from satisfied customers and a list of celebrities who they claim use them. As evidence that magnetic bracelets work, they mention one research article from a famous and well-respected institution. The article was published in a peer-reviewed journal with detailed explanation of their experimental steps and positive results supporting their claim.

The site, however, completely neglects to mention the significant amount of published scientific evidence that they don't work. They also claim wearing copper bracelets are beneficial too.

Question 14 (Question edited for consistency with current BDTK)

Many tools from the Baloney Detection toolkit indicate that this could be complete baloney. However, there is a tool from the kit that *might* argue against it being Baloney upon further investigation. Which tool in the kit is that?

- a) How reliable is the source of the claim?
- b) Where does most of the evidence point?
- c) Does the claimant use flawed reasoning?
- d) Has the claims been verified by someone else?**
- e) What is the source's perspective?

Answers: d

Question 15

The quote from the web site provides a theory for how the bracelets work. Is this a scientific theory (select yes or no) and why (select a reason).

- a) Yes
- b) No**
- c) It explains how a wide range of quite different, many medically unrelated, ailments can be treated with the bracelets.
- d) They provide no evidence that the theory has been tested, plus the explanation in several places is nonsensical.**
- e) The claimed results of the quoted scientific studies from well-respected institutions support the theory (given that they can be verified) as does the evidence in the testimonials.

Answers: b, d

Question 16 (question removed, will not be tested anymore)

Question 17

Over the course of the industrial revolution the total world population roughly doubled every 138 years compared to doubling roughly every 1,400 years prior. Why?

- a) Mortality rates drop across the planet, leading to more people surviving to have children of their own.
- b) The widespread use of synthetic fertilizer led to greater crop yields almost everywhere reducing the incidence of famine across the world and improving human nutrition considerably.
- c) **Those nations that underwent a period of social and economic change that transformed the society from essentially agrarian into one heavily reliant on manufacturing underwent a massive population surge resulting in the world's total population increasing markedly.**
- d) **Those nations embracing new technology and mechanization replacing what use to be done by hand far less efficiently were able to reduce their mortality rates considerably during the industrial revolution.**
- e) The establishment of fledgling scientific societies and the consequent questioning of the reigning authoritarian world views in various nations took place resulting in ensuring the people taking control of their lives leading to much higher birth rates in those countries.

Answer: c, d

Question 18

Question removed as the ISO definition of accuracy is no longer part of the HSI1000 curriculum.

Try this instead:

Upon making 5 measurements of the height of a tree, it was determined to be 10.2 ± 0.3 m tall. Here the margin of error is on the average. If we wanted to reduce the margin of error on the average to ± 0.15 m, we would have to make a total of BLANK measurements.

BLANK = 20, or 4 times as many measurements. This is mentioned in video 4.5 in the interlude (L04.5.2.4 cf detailed notes, power point slide when discussing the points "(i) NB to $\frac{1}{2}$ MoE, need 4x's as many subjects. (ii) Same goes for our MoE on our average (L4.3)".

Question 19

Which of the following constitutes scientific evidence and therefore empirically supports or tests an explanation or claim?

- a) A true expert's opinion.
- b) Sworn eyewitness accounts or testimony.
- c) A physical object that can be probed and examined in every detail.**
- d) Repeated measurements made of a mysterious phenomenon, that can sometimes, but not always, be reproduced under what *appears* to be the same conditions by other scientists.**
- e) An experiment or measurement that can never fail to provide the expected result.

Answers: c, d

Question 20

Which of the following could be classified as scientific theories?

- a) A set of differing explanations proposed for a mysterious phenomenon just observed.
- b) A set of related mathematical equations that when applied correctly reproduce and predict what at first sight appears to be quite different phenomena.**
- c) A set of self-consistent and unifying concepts that when applied explains and predicts many apparently disparate observations.**
- d) An untested but quite reasonable and plausible explanation for a phenomenon or observation.
- e) The written aspect or classroom knowledge base associated with a particular topic or discipline (declarative knowledge) as opposed to the practical, or actually physically doing part of a particular topic or discipline (functioning knowledge).

Answers: b, c