Clear Thinking

Teacher´-s guide

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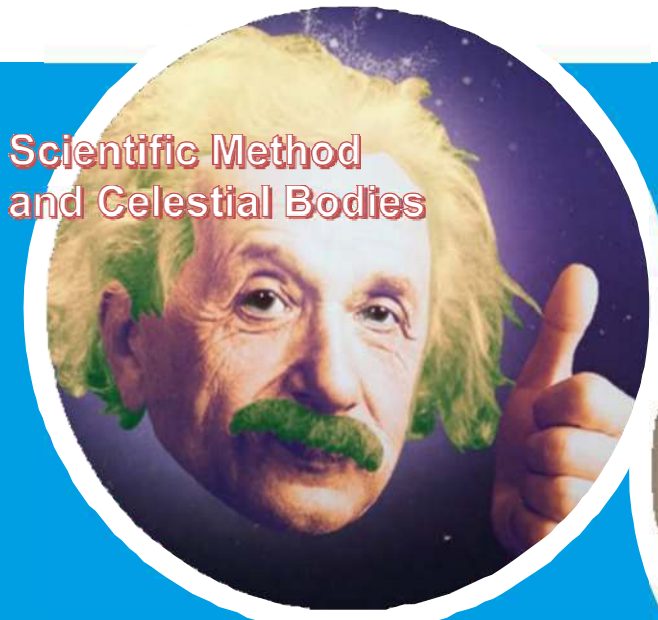


The “Clear Thinking”-project is made up of four videos and this teacher´-s guide.

The videos are produced by Mediabruket AB and commissioned by The Royal Swedish Academy of Engineering Sciences.

The teacher´-s guide was written and commissioned by the Nobel Prize Museum.

Videos in English

pgm 1 eng: Scientific Method and Celestial Bodies

pgm 2 eng: Scientific Method and Vaccination

pgm 3 eng: Avoiding Mind Traps

pgm 4 eng: Argument Fallacies

Clear Thinking

This teacher´-s guide and a series of four seven minutes long films are intended for the education of schoolchildren aged about 11 or older. The goal is to provide them with tools to critically review information and to understand what characterizes scientific thinking.

The first two films describe the scientific method and the difference between science and pseudo-science. The differences are exemplified by comparisons between astronomy and astrology and vaccines and homeopathy.

The last two films are based on ideas about how we think, developed by, among others, the psychologist Daniel Kahneman, who won the Nobel Memorial Prize in Economic Sciences. For example, they are about the incorrect conclusions that we might draw when we think too quickly and intuitively. Using specific examples, they show how to recognize different kinds of disinformation. Students are also taught how to carry on constructive discussions by learning to recognize and avoid argumentation errors.

Contents

page

Clear Thinking 1
Scientific method and Celestial bodies 4

Clear Thinking 2
Scientific method and vaccination.....8

Clear Thinking 3
Avoiding mind traps 13

Clear Thinking 4
Argument fallacies 16

Appendix 1 ..... **19**

Appendix 2 ..... **21**

Clear Thinking 1
Scientific method and celestial bodies

Length: ~ 7 minutes

About 2,000 years ago, the Greek astronomer Ptolemy made some important discoveries. He studied the sky and came to the conclusion that the planets were moving in orbits around the earth. This was the start of the science of astronomy. But Ptolemy also believed that the planets had power over us humans. He wrote a book about the impact of the stars on man and his environment. This became a foundation of astrology.
The film Clear thinking 1 is based on a comparison between these areas. The main message is that the scientific method of studying the world constantly increases our knowledge to the benefit of our society.
What is the difference between astronomy and astrology? One answer is that one is science, the other is not. The film clarifies how to distinguish between science and pseudo-science, that is, notions that pretend to be science but are not.

Content and message

Scientific method

The knowledge of astronomy has increased enormously since Ptolemy'-s made his discoveries. The field developed quickly in the 16th century when a number of astronomers contributed different elements to what resulted in a new and correct description of our solar system. Interestingly, at the same time these astronomers made their living from astrology.

Galileo Galilei, known for his studies of mechanics and for building the first astronomical telescope, confirmed the new world view. He also described the scientific method: Begin with an assumption, a hypothesis. Test this repeatedly and evaluate the result objectively. Try again, unless the hypothesis is confirmed. He stressed the importance of not caring about preconceived ideas and authorities, but to think independently.

There were others before Galileo who advocated the scientific method. An early representative was the British science historian Roger Bacon, who was already active in the 13th century.

Hypothesis and test

Isaac Newton took over after Galileo. He wanted to investigate why the planets move in orbits. His startingpoint was the movements of the planets and Galilei's laws on how bodies move on earth. Newton's hypothesis was that objects are drawn to each other and that the strength of that force depends on the mass of the objects and the distance between them. He tested his hypothesis in several ways, for instance by measuring how the tides vary in different places on the planet. This shows the drag of the moon on the oceans of the earth.

All his tests showed that his assumptions were correct and his so-called gravitation theory

was accepted. On earth, that theory is sufficient. But in space we need further explanations. They were provided by Albert Einstein 300 years later. His hypothesis was that celestial bodies could bend light rays and that this could be observed on earth.

In 1919 it was possible to test the hypothesis. During a solar eclipse, one could see how the light from a star behind the sun bends past the sun and continues to reach the earth on the other side. The validity of the hypothesis was verified.

Einstein's theories of relativity have had a significant impact on technological development. An example is maps based on GPS satellites. They would not be useful if we could not apply Einstein's theory for correcting the signal between earth and the satellite.

There are two factors that affect time: satellite speed and gravity. Time passes more slowly, where gravity is stronger. As gravity is stronger on the ground the time is faster on the satellites.

But satellites move faster than we do on earth and time slows the faster you move. Therefore, the time spent on a satellite is slower than on earth.

These two relative time differences exist between the earth and the satellite and you need to compensate for them. If we did not, the map would be completely wrong.

The film shows that the scientific method leads to new knowledge by building on previous discoveries. Another well-known example of this is the Nobel Prize winner for Physics 1903 (and Chemistry 1911), Marie Curie who studied uranium radiation, which she later called radioactivity. This radiation was discovered by the French physicist Henri Becquerel. But Marie Curie could also make quantitative measurements and managed to isolate two new elements, polonium and radium. Her daughter Irene built further on this work.

Irene Joliot-Curie was also awarded the Nobel Prize in Chemistry, in 1935. She received the prize for the discovery of artificial radioactivity.

Science and pseudo-science

Astronomy is a science that describes the planets, stars and space. Knowledge in the field has increased enormously through the scientific method, enabling for instance man to land on the moon.

Astrology, on the other hand, has not evolved since the idea was first presented in more detail 2,000 years ago.

The difference becomes clear: while astronomy is a science, one can call astrology a pseudo-science, that is, something that pretends to be science but is not.

Many still believe that astrology is a science. In Sweden, the organization "Science and the General Public" found in 2012 that 14% of the population believed that astrology was a science.

Work with the film in the classroom.

Below are suggestions for different tasks to continue working with the film.

Discuss with the students:

The film states that astrology has not developed much during the last 2000 years.

● Why do you think astrology has not developed more?

● Why do you think people believed in astrology?

● Do you know other explanations you have used to explain, for example, illness and malnutrition (which we know today is not scientific)?

● Does it matter if you believe in astrology or not?

● Do you think science is important? If so why?

In the film there are the following quotes by Isaac Newton: "If I'have seen further, it is by standing on the shoulder of giants"

● What do you think he means?

● In what way does it relate to the scientific method?

If you want to work more: Do a survey using a scientific method

The concept of scientific method can be made clearer to the students by carrying out an investigation using it. Based on a question or problem, work systematically to answer or solve it, for example:

● Suggest a hypothesis of a solution that can be tested.

● Test the hypothesis.

● Document the results. Draw a conclusion.

● Accept or reject the hypothesis.

An example that the Nobel Museum's pedagogues use is to investigate “What affects how quickly a helicopter descends to the ground?”

The basis for the study and a protocol (for copying or for wall projection) can be found in Appendix 1 of this manual.

Formulate and test hypotheses

Formulate and test hypotheses by letting the students in the class respond to three alternative choices.

First, give a hypothesis about how many correct answers the students think the class will have on average. Let students answer the questions. How did it go? How well did the hypothesis predict the outcome?

Feel free to repeat the exercise. First, put a new hypothesis about how many correct answers the class gets if you ask the same questions again. (Correct row: 2, x, x)

Questions:

When did Ptolemy live?
1. 1,000
x. 1,500
2. 2,000 years ago

In what century did Newton's apple fall?
1 14th century
x. 17th century
2 19th century

In which year did one see the light bend at the solar eclipse?
1. 1909
x. 1919
2. 1929

Words and concepts

Spiritual leader: Guru, Imam, Priest, Monk.

GPS (Global Positioning System): A satellite navigation system.

Heavenly body: A natural object in space, such as a star, a planet (for example, the earth) or a moon.

Planet: a celestial body that moves in an orbit around a star and,has enough mass to be almost round.

Solar system: The everyday name of our planetary system, including the sun, the earth and the moon.

Tide: A variation in sea level with a period of approximately half a day. The gravity of the moon (and the sun) causes river banks on both sides of the globe. These water collections move over the ocean's surface as the earth rotates around its axis.

Science: the systematic search for knowledge that every-one can retrieve and/or verify. Pseudoscience is a non-science-based approach, but is formulated so that it gives the impression of being scientific.

Further reading

R.B.Culver, P.A.Ianna: Astrology: True or False? Prometheus Books 1988

Clear Thinking 2
Scientific method and vaccination

Length: ~ 7 minutes

Since the late 1700s, when Edward Jenner, started developing a vaccine against smallpox vaccination has saved hundreds of thousands of lives. Today, there are vaccines against a number of diseases that could cause permanent damage to your health or premature death. At the same time as Jenner started to work on vaccines, the concept of homeopathic treatment, was introduced. According to this method of alternative medicine, a substance that gives symptoms to a healthy person can cure the same symptom of a sick person. The film Clear Thinking 2 describes both vaccination and homeopathy and points out the crucial differences between them. Vaccines have been developed using the scientific method. They are tested in many stages before being given to humans. In this way, we know that they have an effect without giving serious harmful side effects. When homeopathic preparations have been tested scientifically, they have not shown any effect at all.

Content and message

Scientific method

In Clear Thinking 2 we again meet the scientific method. We meet Dr. Jenner, who begins to develop a vaccine against smallpox, a disease that at that time killed one in three people who were infected. Dr Jenner uses the scientific method and his hypothesis is that people who have been exposed to harmless cowpox cannot get fatal smallpox.

He tests his hypothesis and then makes the observation that people who have had cowpox do not get smallpox. The conclusion is that the body has been resilient to a severe disease because it has been subjected to a similar, but milder form of infection.

It has long been known that people who survived smallpox became immune. Long before Jenner began his investigations, a method called variolation was used in Asia to provide permanent protection against smallpox. The term comes from the Latin word variola which simply means smallpox. Variolation introduces a small secretion below the skin, causing a slightly contagious infection. It's not harmless, but better than getting the serious infection. The method had been already used in China, India and Egypt already in the 13th century. It spread to Europe from Turkey in the 18th century, primarily by Mary Wortley Montagu, who was the wife of the English ambassador to the Ottoman Empire.

Smallpox has been known since ancient times. Traces of the disease have been found in

mummies several thousand years old.

In 1978, a woman in England who died from smallpox was the last known victim of the disease. In 1980, the WHO (World Health Organization) declared that smallpox had been eradicated. Today, virus strains only exist in two research laboratories, one in the US and one in Russia.

Careful scientific tests

Vaccines contain something called antigen. This is a substance that activates cells in the body's immune defenses so that they attack n various ways the bacteria or viruses that can make us sick. The component of the vaccine that the immune system responds to and which gives immunity can be of two different kinds. Most often, it is an inactive or extinct pathogen (disease-causing virus or bacterium) but it can also be a living but weakened one.

Vaccines and other drugs are investigated in many phases during development into an approved drug. When laboratory researchers find a substance that may be effective against a disease, it is tested on cells in test tubes and in animal tests. This is done to determine which dose is appropriate or if the substance could be harmful.

After that, researchers must apply for permission from the Medical Products Agency to start testing the potential drug on humans. These tests are called clinical trials and may last for several years. First, researchers conduct tests to see if the substance has any side effects, then to see if it has any effect. New medications are almost always tested in so-called randomized double-blind studies. This means that half of the randomly selected patients receive an inactive preparation (placebo) and half receive the effective drug. Neither the researcher nor the patient knows which substance they have been given. This increases the credibility of the result as it removes bias in the evaluation.

Once it is proven that a product is effective without severe side effects, one can apply to start selling the medicine. Once the drug is on the market, and being used by many people very unusual side effects may be discovered.

Positive effects and risks

In Sweden, vaccinations have been used in public health work for more than 50 years. The goal is to protect the population from severe diseases. For example, before the vaccination program was introduced, Sweden had close to 13,000 cases of measles per year, 11,000 cases of rubella and 2,500 diphtheria. In 2016, just three cases of measles were found and no cases of the other two diseases.

Vaccines, like other medicines, can cause side effects. They are mostly rare and mild, and must be weighed against the positive effects of vaccination. However, the vaccine used for swine flu in 2009 had a serious adverse effect. A comprehensive register study conducted by the Medical Products Agency in Sweden together with the Karolinska Institute and seven county councils showed that children and adolescents who were vaccinated had an increased risk of suffering from narcolepsy. This is a neurological disease that affects the brain's regulation of sleep and vigilance.

However, there is no correlation between so-called MMR vaccine (against measles, mumps and rubella) and autism, as claimed in an article published in the scientific journal The Lancet in 1998. The lead author was a British scientist called Andrew Wakefield .

A large number of researchers have subsequently tried to replicate the results in several studies, but could not find any connection. Since then, investigations have shown that Wakefield cheated when he carried out his the study. For example, some children were diagnosed with autism long before being vaccinated. It also came to light that he had economic motives. He had been paid millions to be an advisor for litigation for claims for damages against the MMR vaccine. The Lancet later apologized for the publication and removed the article. Wakefield has since lost his certification to practise medicine.

The claims in the article in The Lancet, however, were widely spread and the number of vaccinations fell sharply, even in Sweden. This in turn led to a rising number of cases of measles and mumps.

Homeopathy

When homeopathy was introduced in the early 19th century, the treatments of established medicine were often more harmful than beneficial. Methods such as blood-letting, as well as ineffective and toxic drugs often made the patient more ill. So at this time treatment without any such effects, such as homeopathy, was progress.

The first known double-blind study conducted was actually on a homeopathic preparation, in 1835 in Nuremberg. The study showed that a homeopathic dilution of salt in water had no medical effect.

Homeopathic preparations have since been tested in several scientific studies without anyone having demonstrated that they have any effect. In 2015, the National Health and Medical Research Council (NHMRC) in Australia published a systematic review of 225 scientific articles on homeopathy. The analysis conducted by an independent expert group included a large number of controlled studies investigating the effect of homeopathic drugs. They lacked any effect, the expert group noted. The NHMRC concluded that homeopathic medicines should be avoided for all disease states that are or risk becoming serious or chronic.

Work with the film in the classroom

Below are suggestions for different tasks to continue working with the film.

Discuss with the students:

- Homeopathic medicines have no effect but can still be dangerous. How would you explain this?
- Does it matter if you believe in homeopathy?
- Why do you think people believe in homeopathy?
- Do you think it is important to use the scientific method when developing medications? Why?
- What arguments do you think can be made for not to vaccinating?

Formulate and test hypotheses

Let the students in the class answer three questions. First, give a hypothesis about how many correct answers students think the class will have on average. Let students answer the questions. How did it go? Did the outcome confirm the hypothesis?
Feel free to repeat the exercise. First, put a new hypothesis about how many correct answers the class will give if you ask the questions again. (Correct row: X, 1, X)

Questions

In which year do you think Sweden started vaccinating against measles?
1. 1951
X. 1971
2. 1991

How many reported cases of measles do you think Sweden had the year before?
1. 12,905
X. 8,409
2. 498

How many reported cases of measles do you think Sweden had the following year?
1. 29
X. 3
2. 0

Scientific method

The Nobel Museum's pedagogues use a short exercise to expand the students' experiences of working with the scientific method (question, hypothesis, method, outcome, and conclusion).
For cards as well as a protocol (for copying or for wall projection), see Appendix 2 of this manual.
The task for the students is to place each of five cards in the **Question, Hypothesis, Method, Result** and **Conclusion** boxes in the table.
1. Milkmaids do not get sick when infected with smallpox. Are they protected because they have had the harmless cowpox?
2. Anyone who had harmless cowpox cannot get life-threatening smallpox.
3. A number of subjects are infected with cowpox and subsequently exposed to contagious smallpox.
4. Those who have been exposed to cowpox do not get sick from smallpox.
5. Cowpox makes the body develop its own substances that can fight the contagion in smallpox, so that you do not get sick.

Further reseach

The University College of Physicians in Philadelphia, USA, has a website, The History of Vaccines. Among other things, you can scroll through a timeline to follow the history of smallpox from the 16th century to today, the spread of the disease, the arrival of the vaccine and the measures to eradicate the disease.
There are also simulations showing how vaccines work. For example, you can compare the risk of vaccinating against a common influenza virus with the risks of being infected by the virus.

Words and concepts

Alternative medicine: Alternative medicine is a collective term for treatments for disease that have not been scientifically tested according to the rules governing established healthcare, or which have been scientifically tested and determined to have no effect.

Active substance: This is the substance of a drug, herbal remedy or other product that gives its medicinal effect.

Homeopathy: From Greek homoios (equal) and pathos (suffering), an alternative medicine system different from school medicine. The starting point is that a substance that can create certain symptoms in a healthy individual can cure the same symptoms in a sick individual. A homeopathic drug is produced by strongly diluting the active substance.

Clear Thinking 3
Avoiding mind traps

Length: 7 minutes

Will something be truer because it is repeated often? Do we prefer what is familiar to us to what is unknown to us? Are we drawn to simple explanations even if the problem is complicated? Do we think more of people we like than those we do not like? The film Clear Thinking 3 points to the different mental traps we can end up in when we think intuitively and too fast. This can result in answers to questions, perceptions and decisions that are completely different from what they would have been if we had thought a little longer about the issues.

Content and message

Mind traps

Within psychology, fast thinking is called System 1 and slower thinking System 2. The first works automatically and quickly without much effort. We use this for simple things such as determining if one item is closer than another, to speak, or read words on large billboards. System 2, which is more demanding, we use for activities that require our attention, like going faster than we usually do, calculate all "a" on this page, or for making more complicated mathematical calculations. Problems arise when we use System 1 when we should be using System 2. That's when we end up in mind traps.

Daniel Kahneman is a psychologist whose research is about our often irrational ways of thinking and making decisions, which is of great consequence to society and economics. In 2002, he received the Sveriges Riksbank's Nobel Memorial Prize in Economic Sciences.

Five traps

The film lists five different types of mind traps. The purpose of these examples is to give tips on how to recognize the traps so that we can avoid getting into them.

Belief and confirmation bias: Our thoughts follow simple well known paths. We hear what we want to hear.

Halo trap: We believe unreservedly in those we look up to or perceive as authorities, even if they address questions that they do not have expert knowledge about. Conversely, we do not listen at all to those we dislike, no matter what they say. The ring of light that can be seen around a shining object such as the sun or the moon is called a halo.

Anchoring trap: An anchor, the first digit we see, serves as a reference that guides our

thoughts in a certain direction.

Availability trap: We perceive reality from (dramatic) images that we keep in our memory.

Pessimist trap: We easily deal with negative facts and are less interested in good news. For example, we believe that a lot of things in the world are getting worse, in reality, it is the other way around.

Studies conducted by the Gapminder Foundation (see below) show this. In the survey, Gapminder Test 2017, they asked, for example, whether the proportion of people living in extreme poverty in the last 20 years has A) almost doubled, B) not changed or C) almost halved. As much as 37 percent of Swedes answered A, 27 percent B and only 36 percent C, which is the correct answer.

Work with the film in the classroom.

Below are three examples of when System 1 is usually not enough, but is deceptively close:

Example 1. A racket and a ball cost a total of SEK 120. The racket is 100 SEK more expensive than the ball. What does the ball cost?
● Answer right away! Think for a moment: How would you respond now?
(20 SEK is the quick answer. But if we think more we will realize that this is not correct since the racket will then be 120SEK and the total will be 140SEK in stead of 120SEK. So the ball must cost 10 SEK.)

Example 2. Read the following statements:
Roses are flowers.
Some flowers wither fast.
Therefore, some roses wither fast.
Is the last statement correct?
● Answer right away. Then think for a moment: How would you respond now?
(It sounds correct but is wrong on further reflection. Some flowers wither fast, but roses may not be one of those.)

Example 3. Money has gone missing from the coffee counter. There are three people in the room we can call A, B, and C. The police ask each of them if they have the money. We know that **at least one of them tells the truth and at least one lies** when they respond.

● A says: B does not have the money ; B says: I do not have the money ; C says: I have the money.
Who is the one who has the money?
(It must be A, for then he and B are truthful while C lies. It cannot be C for then all would be telling the truth. It cannot be B for then all would be telling lies.)

The above problems can also be solved on paper. Provide two sheets of paper to each student and ask them to write down an answer on one of the papers directly. Collect the answers.
Let the students think for a while. Ask them to write an answer again, now on the second piece of paper. Collect the second answers.

● How many correct answers will the class score in the first and in the second try?
● What is the difference?
● Why does the numbers differ?

Discuss with the students

● What we just tested was an example of a mind trap. In what way can you benefit from knowing that they exist?
● What can you do to not get caught in mind traps?
Can you give an example of something you misjudged because you thought it appeared to be the most convenient (belief and confirmation bias)?
● Can you give any other examples of mind traps you encountered or fell into during the past week?
● Incorrect information can be spread as so-called fake news. Could the person who first presented the message be important for its spread (halo trap)?
● What are the risks, if any, when false news is spread? Can you come up with an example?
● What do you think is the answer to this question put in Gapminder 2017:

In the last 20 years, the proportion of people living in extreme poverty...

A. almost doubled
B. not changed
C. almost halved

● Did you think anything other than C is the right answer? If so, what could be the reason?

Further reading

Daniel Kahneman. Thinking fast and slow. Penguin Books London 2012
Hans Rosling. The Ignorance Survey https://www.gapminder.org/ignorance/

Clear Thinking 4
Argument fallacies

Length: 7 minutes

"How can you say that people must stop activities that make the earth warm up? I know you always go by car to school. "

"Heavenly bodies affect us. They do not, you say. But can you prove that they do not? "

The final movie in the "Clear Thinking"- series is about argumentation. The purpose is to alert the students to argumentation errors as in the examples above, so that they get a feel for how they sound and do not get fooled by them. This way they can facilitate discussions without getting caught in argument fallacies that make the conversation lead nowhere. The film illustrates the argument errors with examples from previous films in the series, but also with cases that are common in all argumentation.

Content and message

Argumentation errors are the arguments that often look like a good point, but they are certainly not. In fact, they can destroy conversations and make them lead nowhere. It is easy to trick the recipient who does not perceive the argument fallacy. However, for those who use them they can be effective. Argumentation errors are common in advertising and politics, but students can also find them in conversation with friends, teachers and parents.
Clear Thinking 4 describes a number of different argumentation fallacies. Students can avoid being fooled if they learn to recognize them. In this way, they can also use the language in a constructive way and be a little better at examining misleading information. It may also be useful to remind about the message from Clear Thinking 3: It is often advantageous to turn on the slow System 2 and think for a little longer.

Six type of argument errors to keep track of:

Personal attacks: The counterparty does not respond to arguments, perhaps because they do not have any. Instead, they attack the person with whom they are arguing.

False dilemma: In the argumentation, a complex question is simplified to only two alternatives. However, the truth may be somewhere between.

False compromise: A compromise can be a good way to agree, but not when one position is obviously correct and the other clearly wrong. If you place the truth somewhere between two positions, you have a false compromise.

Slippery slope: The argument is first addressed reasonably but then the use of false analogies lands you with a false conclusion.

Irrelevant argument: An argument is addressed seemingly reasonably, but actually uses

completely irrelevant statements that have nothing to do with the initial issue.

What others do: A special case of irrelevant argument allows the person who argues to avoid taking a stand. The person argues that "everyone else" or "nobody else" does it. The "others" have nothing to do with the matter.

Work with the film in the classroom

Below are suggestions for different tasks to continue working with the film

Dramatize

In the film, we see “clearly thinking” Rasmus argue with “confused Rasmus”, who uses a series of argument errors. Write a script for a separate discussion that shows examples of different argument errors. Work in groups of at least two. Please report the results as a dramatization.

Discuss with the students:

● Can you find any examples of argument errors you encountered on radio, television or on any website in the last week?

● Are there any risks with argumentation errors? Can you come up with an example?

● What can you do not to be fooled by argumentation errors?

Listen to Ross and Phoebe arguing

The TV series -“Friends”- offers many interesting dialogues and opportunities for studying arguments. Search for "Friends - Ross and Phoebe argue about Evolution" on YouTube. The video is in section 2, second season of the series and is just over five minutes long.

Let the students watch at the video and work in groups. Ask them to pay attention to the dialogue and note the arguments and what kind of argument fallacies they are examples of.

The following scenes take place:

Argumentation:

Scene 1 (33 sec) Phoebe compares belief in the Bermuda Triangle with faith in evolution. (false analogy)

Scene 2 (50 sec) Phoebe explains that she does not believe in evolution for the story is too simple. (irrelevant argument)

Scene 3 (1.08 min) Ross defends evolution because it is a long and complicated history. (irrelevant argument)

Scene 4 (2.28 min) Ross tries to present overwhelming evidence proving evolution observed in many places in numerous species of animals over very long periods of time. Phoebe says that the matter that interests her is who has arranged all this. (irrelevant

argument).

Scene 6 (3.49 min) According to Phoebe, evolution is one of the many possibilities and according to Ross, the only possibility. (False compromise. Subjective ideas are compared to well-proven observations.)

Some other scenes have links to the content of Clear Thinking 1 and Clear Thinking 2:

Scene 5 (3.02 min) Phoebe asks why she is not allowed to believe what she wants, and wonders why Ross must convince her.

Scene 7 (4.03 min) Brilliant minds once thought the earth was flat and that the atom was indivisible now we know better. Have an open mind, says Phoebe.

Scene 8 (4.22 min) It's arrogant not to admit that you can be wrong, says Phoebe.

Scene 9 (4.45 min) Ross gives in and says there is a slight uncertainty. Phoebe accuses him of abandoning all his convictions.

Comment on scenes 5 and 7-9: Everyone has the right to believe what they want, but the scientific method can solve difficult and important problems and lead to progress. Other approaches cannot do this and may even be harmful. A society that does not accept evolution, for example, may have a poorer understanding of conservation of biodiversity, sustainable development, energy supply and climate problems.

Science continuously questions today's established truth. If new observations show otherwise, a new description of the reality must be produced that can explain the new observations. It will be the new truth until you are forced to reconsider again due to new facts emerging. The fact that the earth is flat and the atom is indivisible are old truths that have been abandoned. One can thus give up what is believed to be the truth, but only if a multitude of well-established observations contradict what was believed previously.

Appendix 1

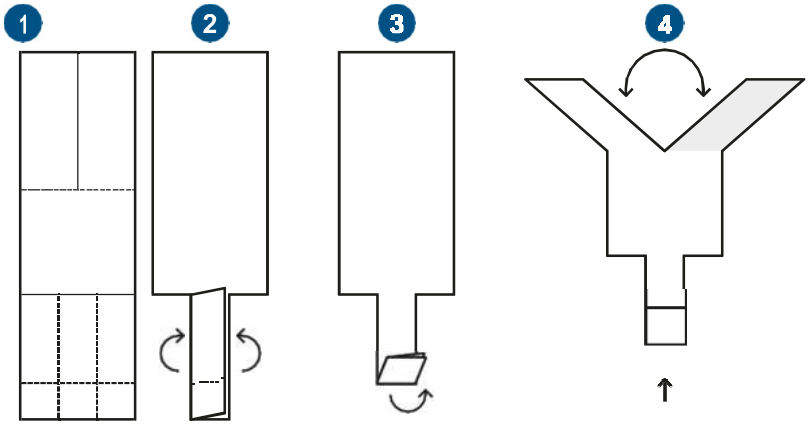
What affects the descent of the helicopter towards the ground?

Build your own helicopter.

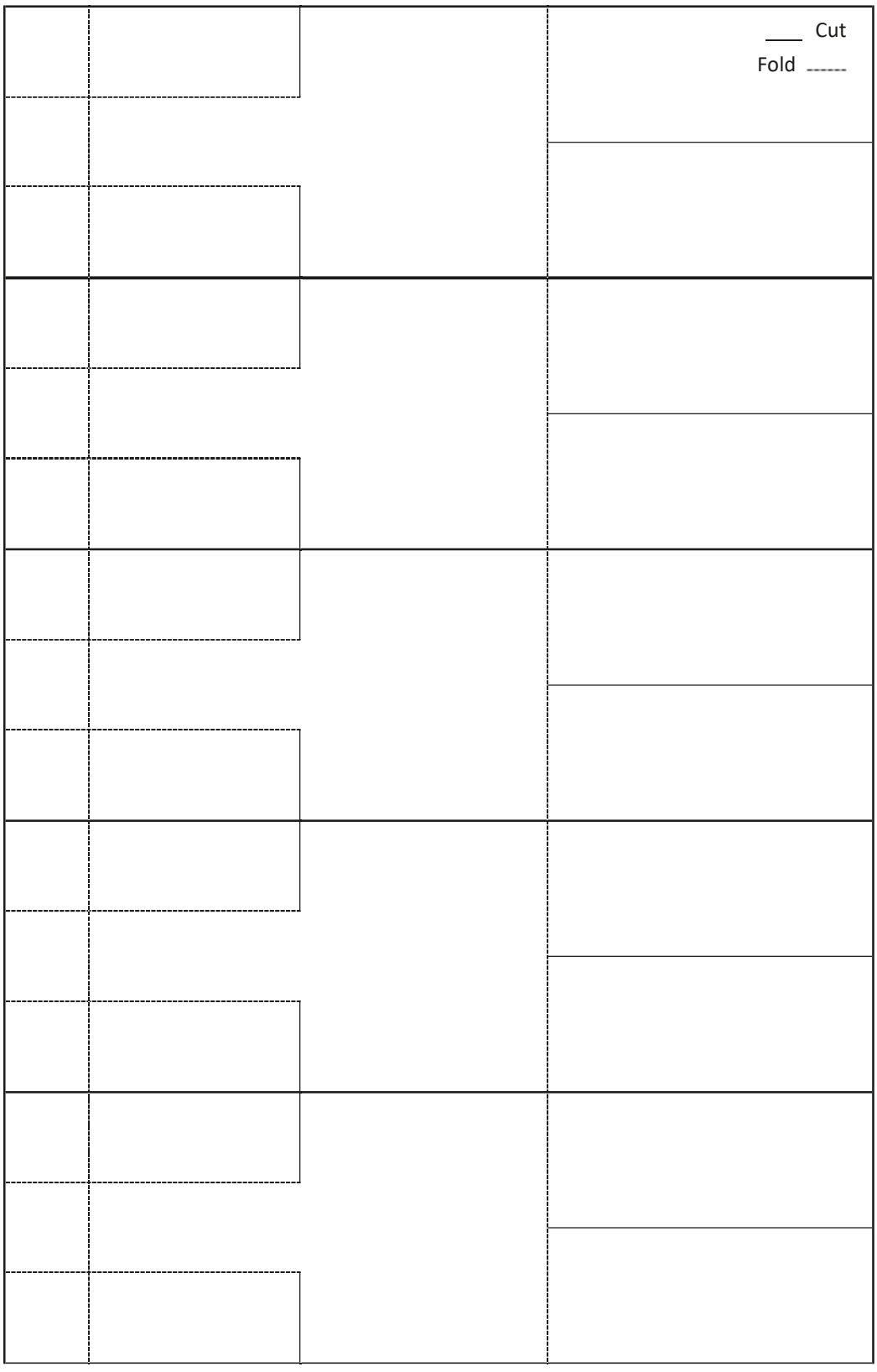
Materials: Clips, 3 preprinted templates and a pair of scissors.

Execution:

1. Make a paper helicopter by cutting and folding the template



2. What do you think happens if you release the helicopter towards the floor from as high as possible?
3. What affects how fast the helicopter moves towards the ground? Record your hypothesis in the minutes!
4. Test your hypothesis!
5. How did it go? Record what is happening in the protocol.
6. Did your results match your hypothesis? Can you explain what happens? Can you draw any conclusions from your experimentation? Record your conclusions in the protocol!


Cut
Fold

Appendix 1, protocol

Hypothesis
Method
Result
Conclusion

Appendix 2, cutout cards

Milkmaids do not get sick when infected with smallpox. Are they protected because they have had the harmless cowpox?
Anyone who has had harmless cowpox cannot get life-threatening smallpox.
A number of subjects are infected with cowpox and subsequently exposed to smallpox.
Those infected with cowpox do not contract smallpox
Cowpox makes the body produce substances that can fight smallpox so that you do not get the disease

Appendix 2,protocol

Question	
Hypothesis	
Method	
Result	
Conclusion	