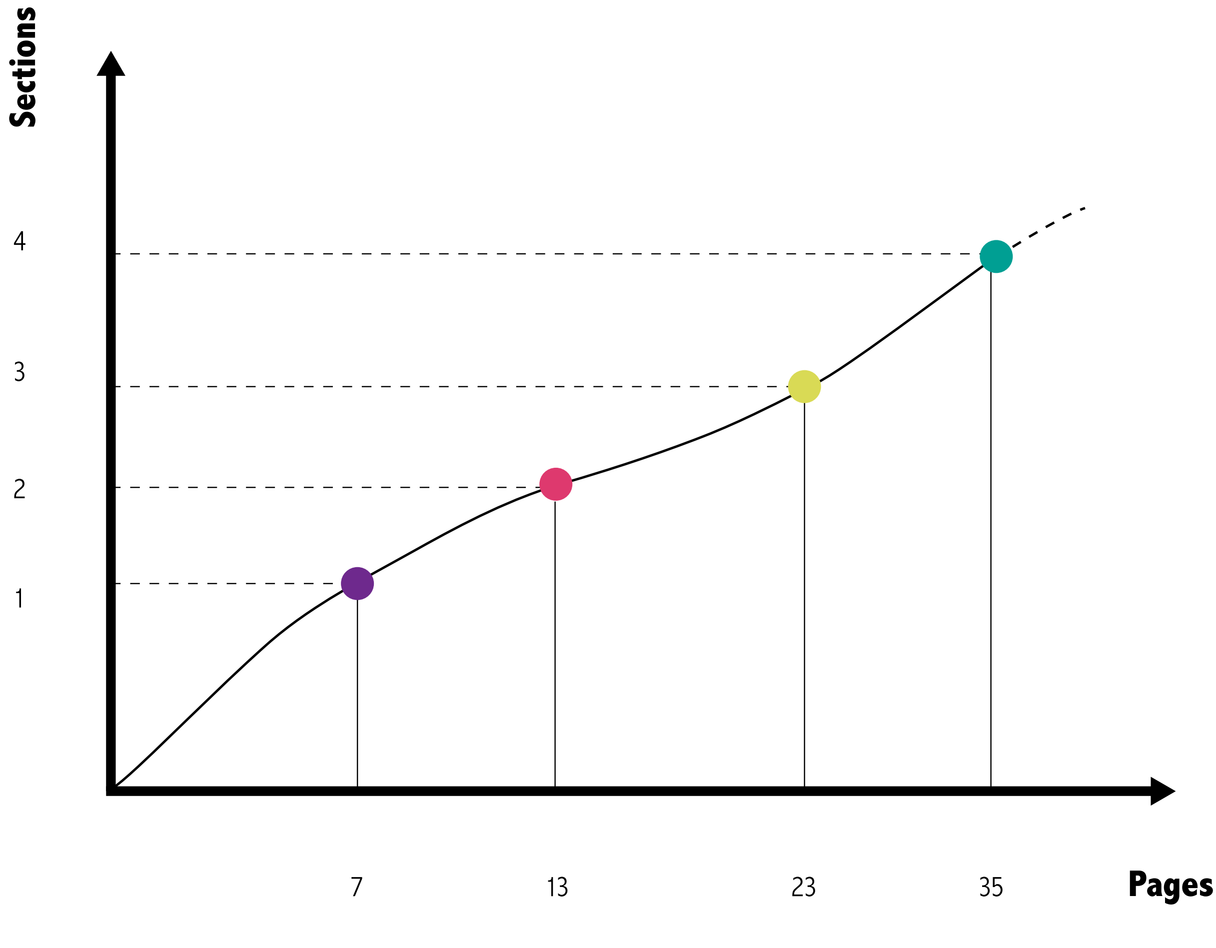
BE A PHYSICIST

CONNECTING EDUCATION AND SCIENTIFIC RESEARCH

CONTENTS



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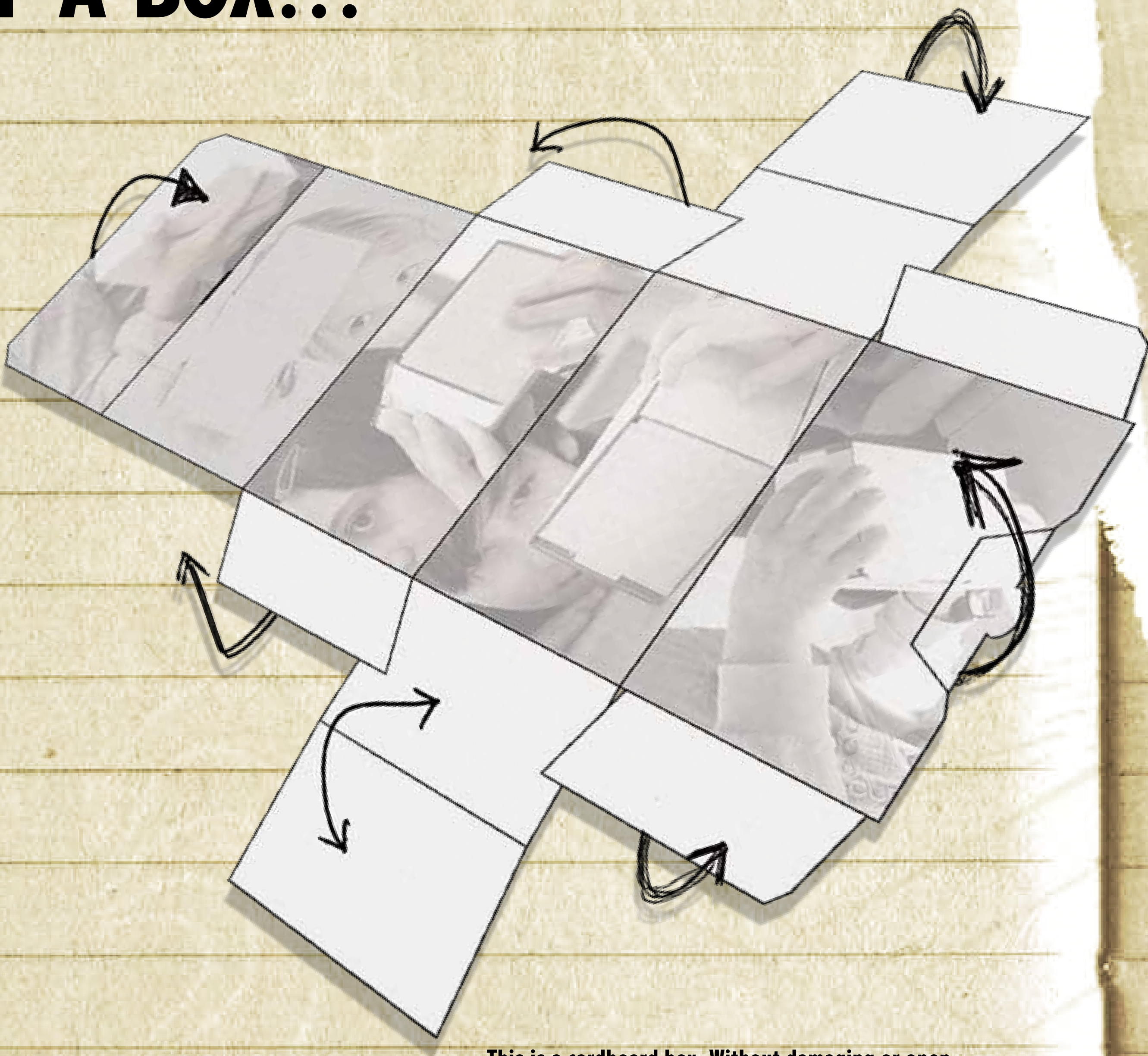
THIS IS THE STORY OF A BOX...



This is a cardboard box. Without damaging or opening the box, you are going to identify what is inside as precisely as possible.

The «Be a Physicist» project offers teachers and their pupils the opportunity to work in an investigative way like real scientists. Just as physicists at CERN search for invisible elementary particles, pupils will conduct investigations to identify the contents of mystery boxes they cannot open by successive hypotheses and experimentation.

This process is designed to teach pupils aged 9 to 12 participating in the project how to build up know-how and take a scientific approach to their work.

Classes involved in this research can produce written reports and share their progress via a collaborative website. They will also be able to compare their approach with that of real scientists by visiting a laboratory or inviting a researcher to come and explain the scientific approach.

This kit includes the necessary tools to carry out the project. It contains a booklet setting out the theory and containing practical information for implementing the class project. It also includes mystery boxes and control boxes.

1 MAIN CONCEPTS

SCIENCE IN BRIEF

INVESTIGATION: ASKING THE RIGHT QUESTION

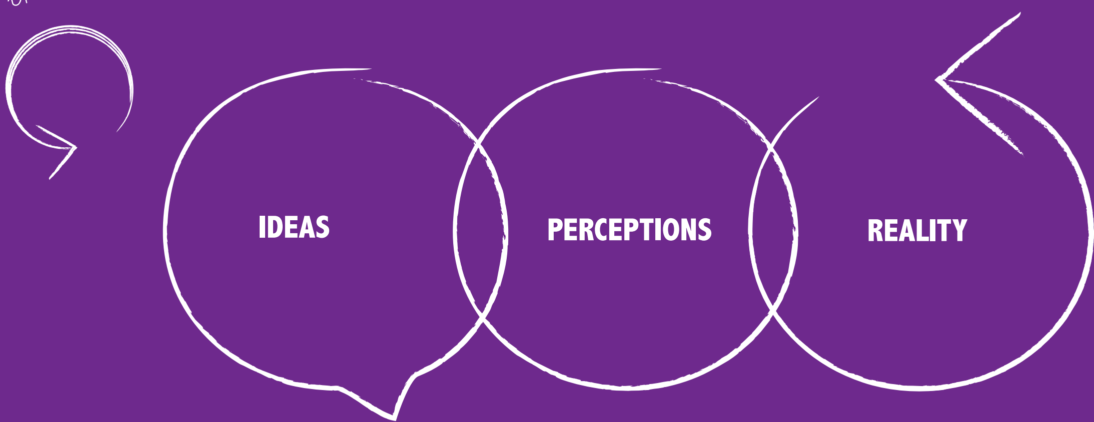
SCIENCE IN BRIEF

Science is:

"...The way in which we describe natural objects and phenomena, alongside the arts, religion and philosophy. The main characteristic of scientific discourse is objectivity; its framework is reason, which is often built on intuition and hypotheses; and its justification is based on verification through experimentation."

Public Education Department, Geneva. 2000. Objectives of primary teaching, 2000.

Karl Popper's three worlds



"The scientific community aims to produce scientific knowledge through investigative methods which are rigorous, verifiable and reproducible.

Scientific methods and values allow us to understand and explain the world and its phenomena in the most basic way possible, i.e. to produce knowledge that is as close as possible to observable facts. Unlike dogmas, science accepts criticism; scientific knowledge and methods are open to being challenged. Scientific results constantly require reality checks.

Science also has the aim of making reliable predictions and developing functional applications which can have an impact on society."

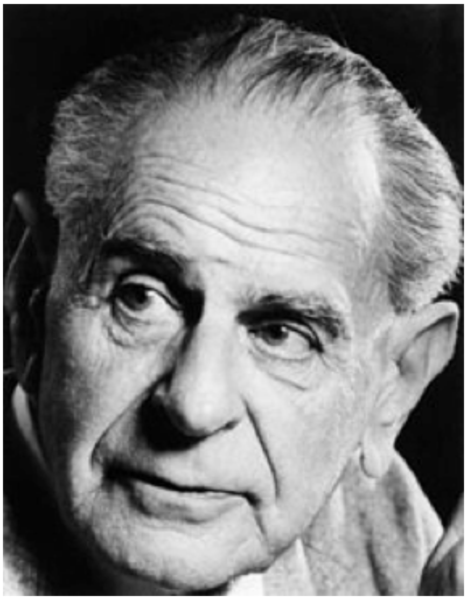
THE INVESTIGATIVE PROCESS FROM 2000

At the start of the 2000s, in most Western countries, new scientific curricula emerged, marking a move away from a teaching method based almost exclusively on the acquisition of theoretical knowledge. In response to the shortcomings of pupils in processing scientific problems and a declining interest in scientific courses, a group of experts at the European Commission recommended the introduction of an approach based on the investigative process. This method, initiated in the late 1990s in English-speaking countries (viz. US National Research Council, 1996), places just as much emphasis on the development of skills and pupil motivation as on the acquisition of scientific concepts. In this way, the aim of science teaching was clearly repositioned: the acquisition of knowledge was rendered subordinate to teaching aimed at developing the scientific process, approach and culture in pupils. The experimental process thus gradually gave way to the investigative process, with the more explicit goals of developing practical know-how and skills.

Karl Popper was a 20th century philosopher. His work was based on the idea of using falsifiability as the criterion of demarcation between what is genuinely scientific and what is art.
By this he meant that a theory can be tested, subject to debate and disproved.

He argued that, through a process of tentative theories and error elimination, scientific ideas and knowledge evolve and advance on a trial-and-error basis that is identical to that described in Charles Darwin's theory of natural selection.

Karl Popper also defined three worlds which have an adaptable and retroactive effect on each other.
World 1: reality, the world of physics, chemistry and biology.
World 2: the world of perception and essentially subjective mental activity.
World 3: the world of ideas, things produced by humans and objective knowledge.



LSE Library - Wikipedia

INVESTIGATION: ASKING THE RIGHT QUESTIONS

The investigative process is distinct from processes based on presentation and illustration.
It puts emphasis on experimentation and training of the senses and motor skills, as opposed to spoon-feeding with scientific laws. Establishing models and concepts are essential parts of this process. This approach takes as a premise that knowledge is not acquired by experience, but by moving back and forth between models, concepts, experiments or observations.
The teaching of science based on investigation derives from the investigative process used by scientists.

PRINCIPLES OF THE INVESTIGATIVE PROCESS

Unity: Continuity between initial question, investigation and acquisition of knowledge, skills and know-how.

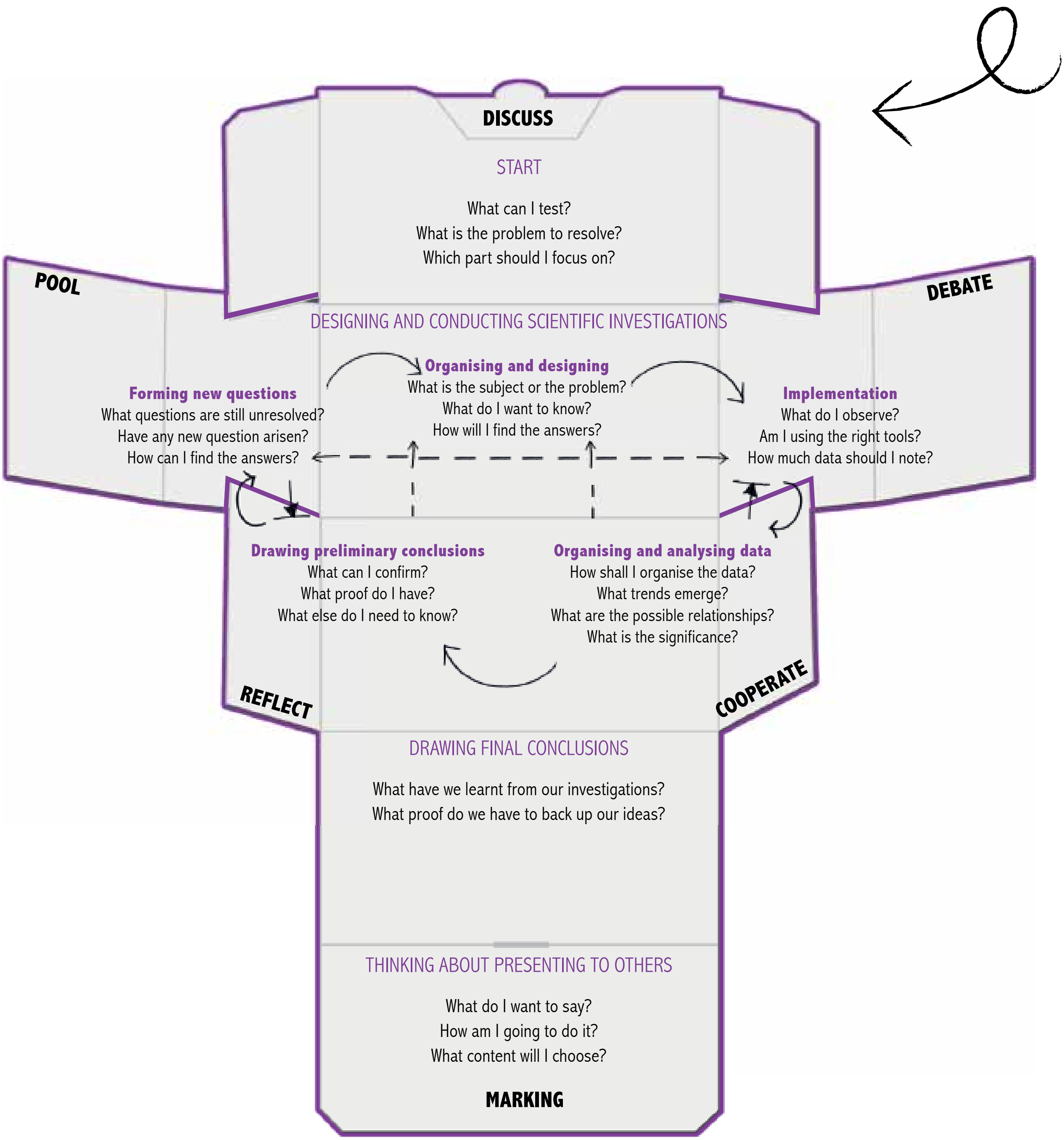
Diverse methods: Material processes, observations, research in documents, surveys, visits and experiments.

Key moments: Starting point, initial question, identifying the problem, making hypotheses, planning the investigative process, the investigation itself, and acquisition and structuring of knowledge.

SOME ESSENTIAL PRECAUTIONS

This system cannot be summarised as a set of steps to follow. The numerous arrows in the design and investigative process indicate that it is not a linear process.
Scientific investigation, whether done by a pupil or a scientist, is a complex process. The steps described in the diagram will sometimes have to be reconsidered: some will require more attention than others. Depending on the subjects covered and the nature of the intended investigative approach, the teacher should plan to emphasise certain stages of the process, but not all steps will necessarily be included in each session.

This teaching process is illustrated by the diagram opposite.



2 PROJECT INGREDIENTS

THE BOX AND ITS CONTENTS

MAIN STEPS

PROPOSED WORK SEQUENCE

THE BOX AND ITS CONTENTS

The objects in the box have been chosen in order to highlight various scientific concepts and will encourage the pupils to come up with a variety of different investigative processes. For example, they offer the opportunity to think about the properties of matter, forces and movement, identify the characteristics of living things and make use of several senses. Various ways identifying the contents of the box can be imagined: working on sounds, the movement of objects, smells, magnetism of metallic objects, etc.
To avoid influencing pupils in their research too much, teachers are encouraged to establish a level playing field with pupils by pretending that they do not know the contents of the box. On the other hand, teachers will have clues as to the content of the box via the "WHAT IF" list on page 19.

PREPARING THE BOX

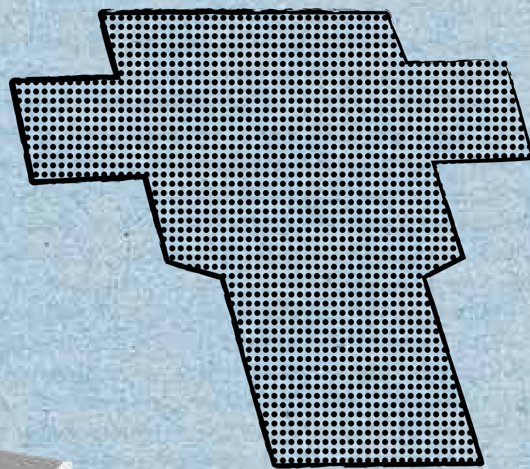
- A TEACHING MANUAL
- OPAQUE BAGS CONTAINING THE OBJECTS TO DISCOVER
- UNFOLDED BOXES
- AN X-RAY

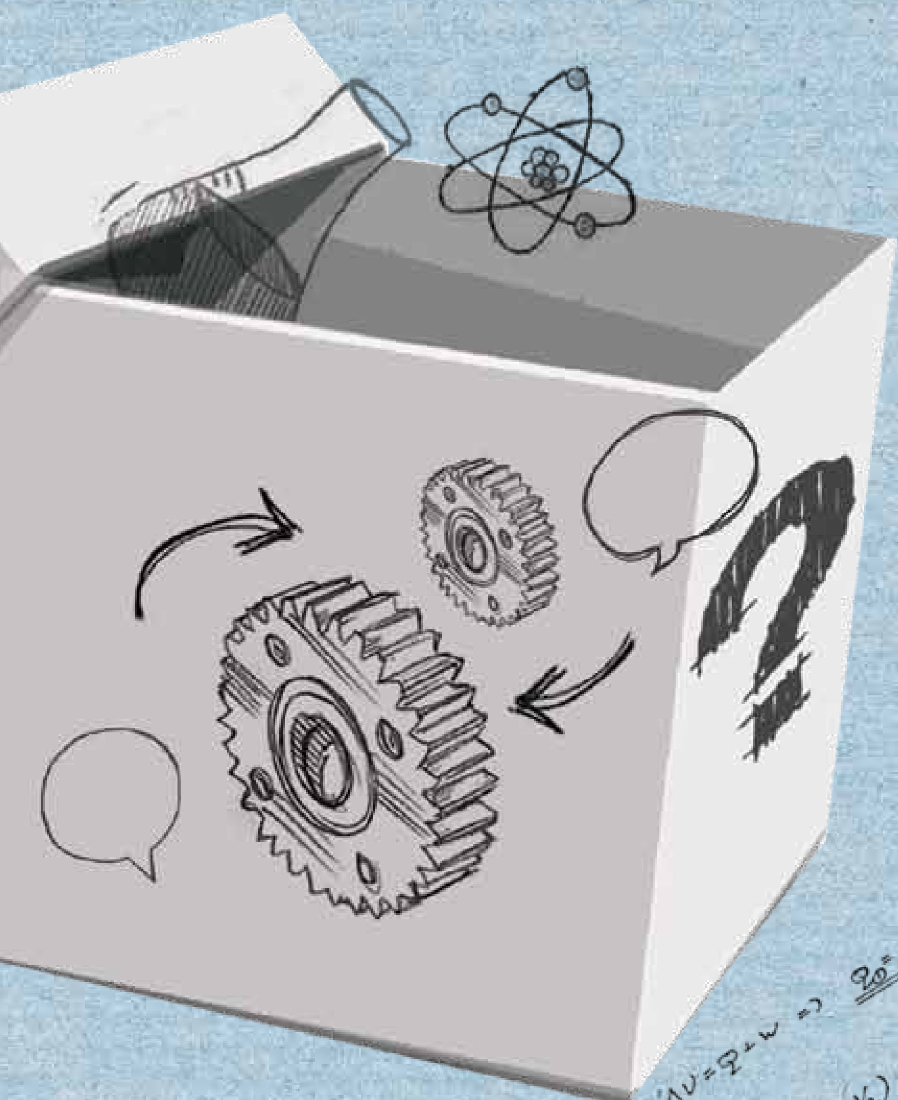
Ingredients / Preparation

1. Assemble all the cardboard boxes.
2. Put an opaque bag in each cardboard box.
3. Put an opaque bag in each cardboard box.
4. Close the filled boxes.
5. Keep the empty boxes open for the experiments.

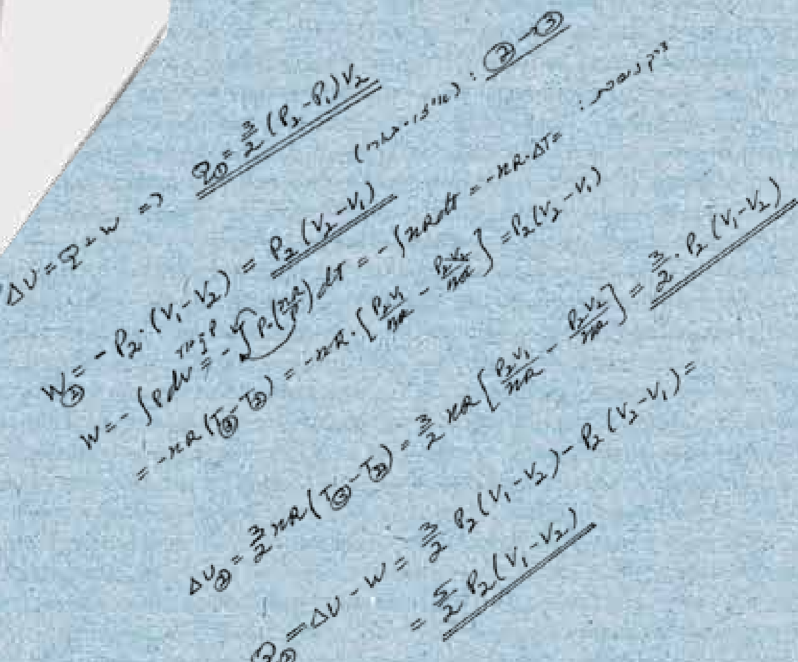
YOU'RE READY!

4





The box is quite thick (minimum 1.5 mm), with approximately the following dimensions: 15 cm x 13 cm x 10 cm.



MAIN STEPS

OBSERVATION

To start with, pupils should simply observe the box, without touching it, and make some predictions about its contents. *** The only clues they will have are: the size of the box, the material, etc. These clues will already allow them to eliminate liquids, large objects, etc.

HANDLING

In the second stage, they are allowed to handle the box. The pupils will think of new strategies, deriving from their perceptions of objects moving about in the box, the noise, the smell given off, etc.
"There is a round object rolling about." "It's not very heavy."
"There are several objects." "It has a spicy smell."
"The objects are different weights." "We can hear different noises."

EQUIPMENT

The third stage for the pupils is to identify equipment that will allow them to find out more and to see if their initial predictions
can be validated or invalidated by one or more experiments. Pupils should be allowed to use whatever equipment they want to. They will have the usual classroom equipment and can bring in
equipment that they find at home. They are given a cardboard box (control box) of the same size as the mystery box.

***This is a cardboard box. Without damaging or opening the box, try and identify what is inside as precisely as possible.

EXPERIMENTS

The fourth stage of the process is to carry out experiments. The length of time spent on this stage will vary depending on the number of experiments being carried out. Teachers may organise these lessons in quick succession so that it is easier to organise the equipment and less time is wasted.

ANALYSIS AND VALIDATION

The fifth stage entails analysing and validating the different equipment and learning how to distinguish between "raw data", "observations and/or deductions" and "interpretations". At the end of this stage, the use of other equipment may be necessary in order to refine the initial interpretations.

COMMUNICATION

Classes are invited to meet researchers to compare their respective experiment procedures. The teacher may organise a visit to a scientific laboratory near to the school or invite a researcher to the class.

New information and communication technologies also allow other options, such as video conferences for example. In cases where several schools located near to each other are participating in the project, classes can organise an "end of project" conference in order to present and discuss their results like real scientists.

PROPOSED WORK SEQUENCE

1st STEP	Contents	Working methods	Suggested duration
Observations **Guesswork**	Presentation of the box. Guessing about its cintents through visual observations. Introduction: "This is a cardboard box. Without damaging the box, try and identify what is inside as precisely as possible."	In group, orally. Written record on the board + a secretary to note things down.	Brainstorming + visual observation + guesswork In total : 1 hour 30 mins
	In a second phase: Split into groups. Further round of guesswork.	Working in groups on a poster, then presenting to the class on the board. Collective written record.	

Written work: List of guesses by the whole class.

2nd STEP	Contents	Working methods	Suggested duration
Proposing experiments to test the guesswork	Using the guesses from the previous lesson, the class, split into groups, should now draw up a list of the experiments and investigations which could be done, directly with the box (non-destructive methods) and, in parallel, without touching the box. What data will be collected? How will the data be processed and analysed? Collate all the groups' ideas with the whole class. Draw up a schedule for the experiments and a list of equipment needed.	In groups, orally. Notes on the board. Work in groups on a poster. Collating all the ideas.	Total: 1 hour to 1 hour 30 mins.

IN BRIEF

The pupils carries out a scientific investigation :

- Defining the problems to be solved
- Identifying a scientific question
- Organising the investigation
- Thinking about the equipment needed
- Evaluating the equipment used
- Reasoning, discussing, writing, researchings, collaborating
- Communicating the results of the work

Write-up of the experimental process or adaptation of an experiment previously proposed by another class.

3rd STEP	Contents	Working methods	Suggested duration
Carrying out experiments and initial conclusions	Carrying out the experiments. Processing and analysing the data. Depending on the results, making new guesses and proposing new experiments. Drawing initial conclusions.	Working in groups on posters. Collating all the ideas. Collective written record.	Several 1 hour 30 min sessions, depending on the number of experiments carried out.

Written work: Write-up of the various experiments carried out and conclusions.

What if ?

A list of questions which pupils might ask.

What if there was ... in the box

- An animal
- Something made of fabric
- Something that smells
- Spices
- A seed
- Several small similar objects (drawing pins, paperclips, beads, etc.)
- An iron object
- A marble (made of glass, wood, another material)
- Something that makes a noise
- A magnet
- Something living
- Something wet

4th STEP	Contents	Working methods	Suggested duration
New investigations	Carry out investigations with other tools (X-ray, etc.). Process and analyse the data, then draw new conclusions. Work on the status of scientific "write-ups"	Working in group on posters. Collating all the ideas. Collective written record.	2 hours

Written work: Write-up of experiment reports.

5th STEP	Contents	Working methods	Suggested duration
Experiment with destrcu-tive method	Propose destructive investigation methods. Each group carries out an ex-periment with its box and notes the results	Orally and in groups. Working in groups. Collating all the ideas. Collective written record.	1 hour 30 mins

Written work: Write-up of experiment reports.

6th STEP	Contents	Working methods	Suggested duration
Preparation of the visit	Prepare for the visit to the research laboratory + prepare the interview with the researcher.	Orally and in groups. Working in groups Collating all the ideas. Collective written record.	1 hour 30 mins

Written work: Write-up of experiment reports.

7th STEP	Contents	Working methods	Suggested duration
Project finali-sation	Creation of a poster.		One or two 1 hour 30 mins sessions

Written work: Posters.

8th STEP	Contents	Working methods	Suggested duration
Visit and inter-view	Visit to a research laboratory or a place where researchers work. Interview with a researcher.		3 hour school trip: 1 hour for visit 1 hour for interview 1 hour for journey

Written work: Account of the visit + photos.

9th STEP	Contents	Working methods	Suggested duration
Final confer-ence	Conference with spokespersons from the classes + poster session.		3 hours

3 WORKING TOOLS

THE TEACHER'S ROLE

FROM DATA TO THEIR INTERPRETATION

SCIENTIFIC WRITE-UPS

USEFUL WEBSITE

THE TEACHER'S ROLE

Before the project, teachers organise the class, the equipment, the working time, etc. Then, throughout the research, they encourage reflection and questioning, and give priority to trial and error and personal hypotheses.

The teachers lead the discussion so that all the pupils can express themselves, by establishing an atmosphere of listening and tolerance, and by defining rules in consultation with the class.
They validate good ideas and encourage the pupils to try again in the event of failure. They help set up the experiments and coordinate the various different pieces of equipment used.
They essentially play the role of moderator and guide, giving pupils access to a range of references, comparisons and collaboration with other pupils or other teachers.
They often have to encourage, restart, reformulate and validate. The teachers must develop teaching strategies which allow pupils to take control, to ask themselves questions and to analyse with complete autonomy.

In brief

The teacher organises the work:

- Reminder of previous activities
- Indicates working time
- Sets the conditions: individual, in small groups or whole class
- Provides the equipment
- Arranges the tables
- Provides a clock so that deadlines are respected
- Concludes each lesson
- Invites the class to give a brief collective conclusion, for example, "What have we learnt today?"

After having taken ownership of the question asked, pupils should work on the following tasks as part of their investigative process:

In brief

The teacher organises the questioning, asking questions that encourage the children to think for themselves, for example:

- What differences and similarities do you observe between these different situations?
- Why do you think these results are different from other tests?
- What would happen if… ?
- How would you… ?
- How do you explain… ?
- How can you be sure of… ?

• Questions, observations, hypotheses that lead to experimentation
• Analysis of results, questioning of the procedure
• Summary of results and communication to peers
• Writing comments on the equipment used by other groups

Throughout the process, pupils should be encouraged to listen to, share and show respect for each other's ideas.

The teacher should remain relatively in the background, adopting the position of mediator or moderator and should be prepared to structure chaotic, lively and enthusiastic discussions.

In brief

The teacher asks questions starting with: In your view / In your opinion / Do you think

The teacher notes down the pupils' questions and then sorts them into categories:

- Those which the investigation may answer
- Those which he may answer
- Those which the interview with researchers may answer
- Those which connot be answered

FROM DATA TO THEIR INTERPRETATION

During the process, it is important to teach the pupils to distinguish between the statuses of the information that they gather. There are three statuses for this information: raw data, observations and/or deductions and interpretations. Thinking about these distinctions gives pupils the opportunity to take a step back from their equipment. This work encourages them to re-examine the question of "scientific proof" by constantly reviewing the usefulness of their equipment in the light of the positive or inconclusive results that they obtain. This is one of the essential learning aims of this project.

Equipment What I use to answer a question.	**Raw data** The information that I receive with my senses (what I see, what I measure, etc.)	**Observations and/or deductions** What i can deduce based on the raw data.	**Interpretations** What I can imagine or explain, taking into account all of the information gathered.
Research question: Is there a metal object in the box?			
We started by putting a pair of scissors in a cardboard control box. Next, we closed the box and then moved magnets one after another around the box to determine whichmagnet was the most powerful to attract the scissors. Then we tested the chosen magnet on the mystery box.	The magnet remained stuck to the mystery box. It did not behave in the same way as with the control box with the scissors.	In the mystery box, there is an object which attracts the magnet. This object is not a pair of scissors.	In the box, there is at least one metallic object which attracts the magnet.
Research question: How many objects attracted by the magnet are there in the box?			
We took two magnets and positioned them at two different places on the mystery box.	The two magnets remained stuck to the mystery box in two places.	In the mystery box, there are at least two objects which attract the magnet.	There are at least two metallic objects separated from one another. These two objects attract two different magnets.
Research question: Where are the objects attracted by the magnet positioned?			
When we move the magnet around on the box...	One of the two magnets and the object that it attracts can be moved around the whole box. The other magnet remains stuck to its object and cannot be moved.	We get the impression that one object is loose in the box and the other is attached to a wire.	There are therefore at least two metallic objects in the mystery box. One of them is loose in the box. It can be moved around and stays stuck to the magnet. The other metallic object does not move. It seems to be stuck or attached to the mystery box.

RAW DATA

That which can be perceived by the senses and/or measured. Raw data are gathered from the experimental equipment. The data then have to be processed.
For example, X-rays are part of this category. They are simple images of objects which are sensitive to X-rays, which then need to be decoded.

OBSERVATIONS AND/OR DEDUCTIONS

That which can be deduced or derived as an argument directly from the raw data.
For example, in the case of an X-ray image, a round object observed could be a plastic disc stuck to the box or a marble.
With the X-ray apparatus, we cannot go any further with our deductions. We need to make use of other equipment in order to gather other raw data and obtain a range of evidence which will allow us to interpret what the object is.

INTERPRETATIONS

What the range of evidence allows you to imagine and/or explain. Interpretation is based on a combination of different results.
For example, we can say that there is a range of evidence that allows the pupils to reach the conclusion that there is a marble in the box, but without being sure of it.
Only concern the properties or characteristics of the material can be deduced with any certainty.

SCIENTIFIC WRITE-UPS

Writing up the experiment results allows a record of the research to be kept and the conclusions to be communicated. This may be done collectively or individually and may take different forms: texts, note taking, labelled drawings or diagrams, graphs, photos, etc.

A TOOL FOR WORKING ON LANGUAGE

Language learning cannot be disassociated from other types of learning. During the investigative process, writing comes into its own and is indispensable. The pupil can see the need for this at all stages because it drives the scientific project forward. Encouraged by the teacher, pupils will want to remember their questions, write the list of equipment they will need for his experiments, draw a diagram of the set-up, etc. In this way, pupils learn the vocabulary and use new types of writing because it is useful and makes sense for them. Write-ups of different types will exist side-by-side in the pupil's exercise book.

WORDS FOR SCIENTIFIC PROCESSES

During a scientific investigation, speaking and writing helps pupils to think and structure their thoughts. They have to continuously think about what they have done and what they want to do. Writing can also prompt questions that the pupils did not initially foresee. Writing in science helps with defending a point of view orally and participating actively in committed scientific debate. At school, building up scientific knowledge is often linked to learning to express oneself clearly.

In brief

Pupils are required to produce different types of written work individually:

- Action: they specify the equipment they are using, predict the results, list the equipment, plan.
- Memorisation: they keep a record of their observations, research and reading. They review their activities and make the results available.
- Comprehension: they reorganise, sort, structure and compare their written work and reformulate collective written work

TO HELP PUPILS TO WRITE

To get the pupils writing, we can ask them the following types of question:
What is the question? What can we do to answer it?
What have I found out? How did I do it? How could I do it better or differently? In what way does what I have done answer the question? Are my results compatible with other people's results? Are the group's results compatible with scientists' results?
Collective writing by the whole class may answer the following questions: What do we know about the subject? What are the problems to resolve? What have we done? What have we observed? What provisional conclusions can we draw?

ORGANISING WRITE-UPS

At a personal level, the pupils explain what they think, what they have understood and what they have seen. They write with their own words and in their own style. They may make spelling mistakes and then revise their writing to correct them.
This part is evidence of the pupils' development and reflects the trial and error process.
Collective writing allows work on language and results from collective negotiation and validation processes, provisional or otherwise.
The writing may result from group work or be created by the whole class. Firstly they need to agree and make choices. They obey stricter spelling and syntax rules than for their own writing.
It is important, in the interests of increased readability, to distinguish between individual writing and collective writing. Some teachers use different coloured sheets of paper; others advocate using different coloured inks or even pictograms, stickers, etc.
Posters are communication tools which should be centred on the essential message to be conveyed.

CREATING A POSTER

The difficulty when designing a poster is attracting the attention of the reader from the first glance. The poster must be attractive and easy-to-read, so that the reader will want to spend time understanding the content. Some simple rules to take into account to achieve the desired effect:

To write a report in the same way that scientists do, you must ensure that your report includes all of the following:

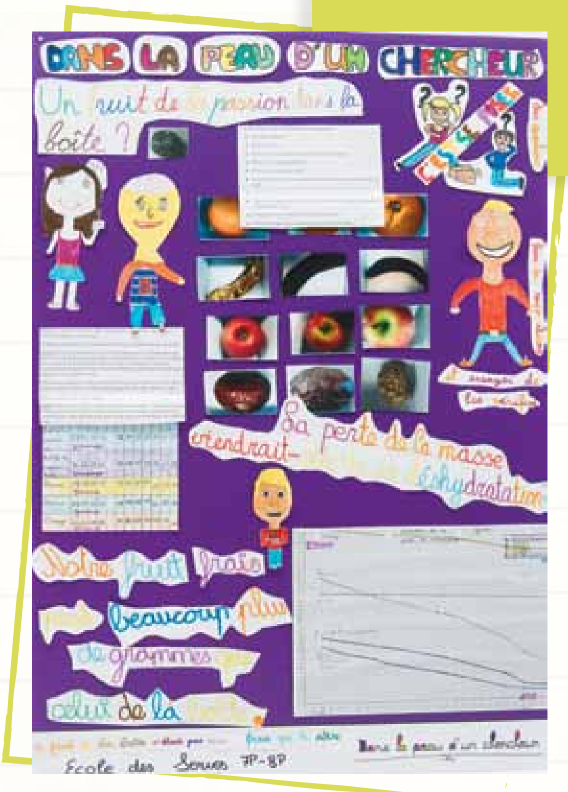
Title
Names of the authors and their institution
An introduction
Experimental equipment in the form of sketches and/or diagrams and/or drawings and/or tables and/or graphics.
Results
Conclusions
Acknowledgements
References

- Limit the amount of text; the reader should immediately be able to see the poster's message.
- Choose meaningful images which illustrate the concept directly and effectively.
- Limit the number of different fonts.
- Leave plenty of space on the poster, positioning texts and illustrations clearly.
- Use appropriate font sizes to rank the information presented.
- Don't use too many different colours.
- Choose a background colour which contrasts with the colour of the text and illustrations.
- Don't forget that the reader will read from top to bottom and from left to right.

In brief

Collective write-ups serve the following purposes:

- Transmit what has been understood, a conclusion, a summary.
- Ask questions to another class or a scientist.
- Explain what has been understood, refer back.
- Summarise, rank and compare the information.



USEFUL WEBSITES

The "Be a Physicist" website is available at the following address:

www.danslapeaudescientifiques.com

On this site, you will find some of the information contained in this booklet, as well as other useful content relating to the setting up of the project.

The project also makes use of a collaborative Internet feature, otherwise known as the collaborative web or web 2.0, and allows all participants to meet up in the same digital space. By making a social platform, or social network, available, we are allowing everyone to find useful information and resources for the project, but also to create and publish content (texts, photos and videos). In this way, teachers and pupils are invited, at each stage, to publish a logbook covering:

- Initial guesses
- Progress of the investigations
- Equipment used
- Comments on the equipment used by other classes

A learning community is made up of a group of individuals working together for a fixed period of time to successfully carry out a task and understand a new phenomenon or complete a collaborative task.

Riel and Polin, 2004.

This social network is a virtual learning community, according to France Henri, who states that participants "build a micro-culture together which defines their identity and represents the main vector for their learning method".

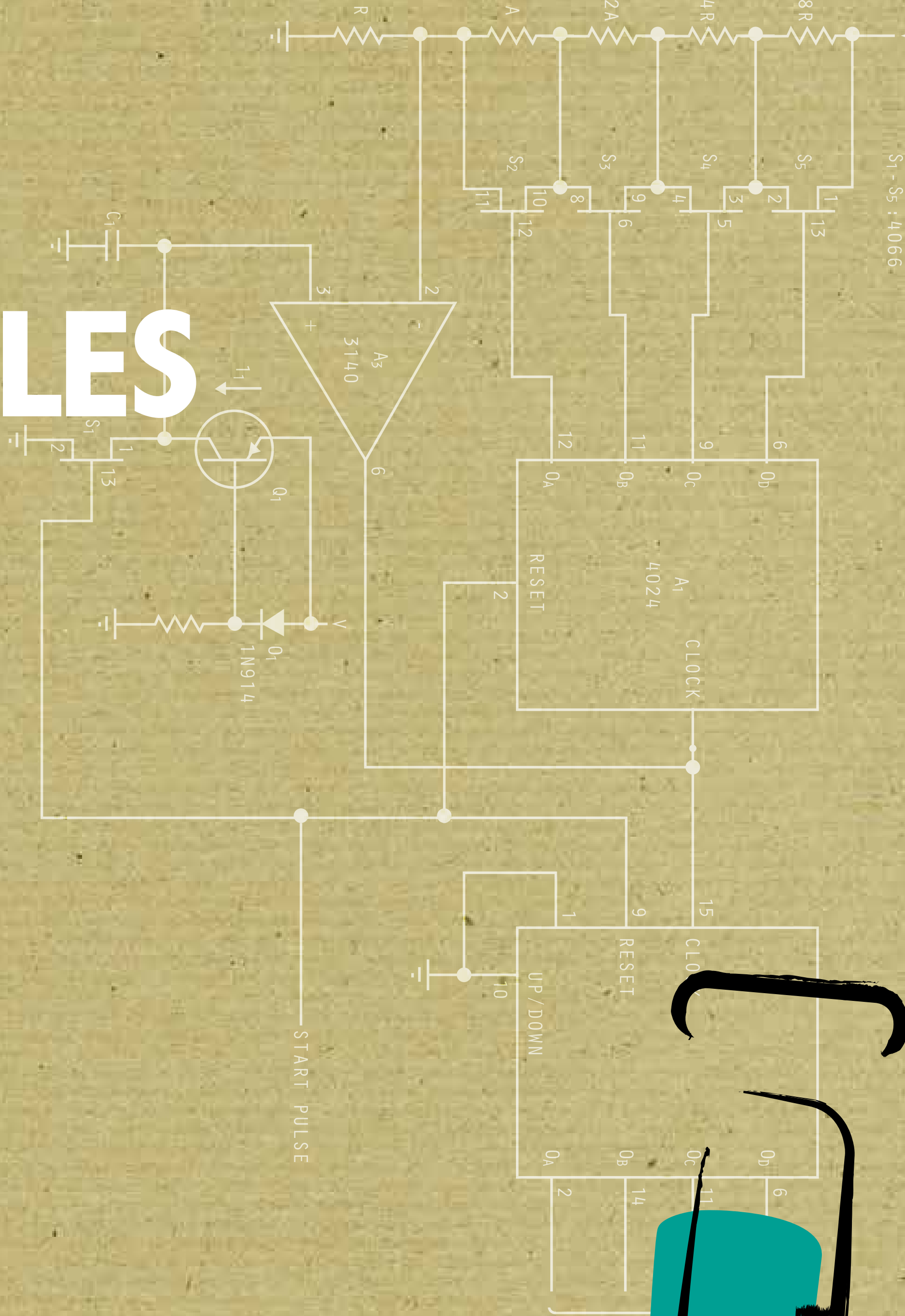
Henri, 2010.

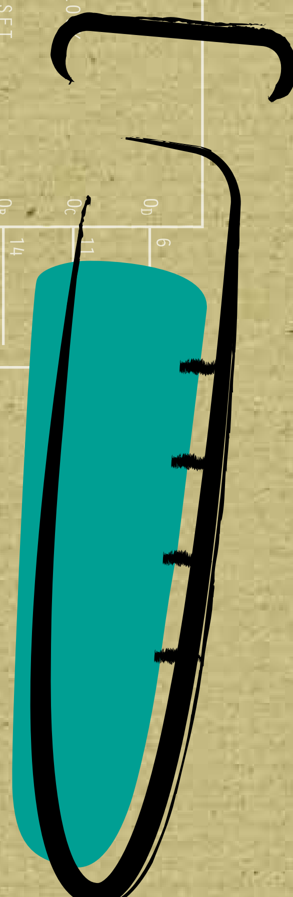
Example of a social network home page:
http://danslapeaudunchercheur.ning.com

PROJECT SITE

CLASSWORK SITE

4 EXAMPLES





EXAMPLES OF EQUIPMENT USED IN CLASSES

PATHS FOR EVALUATION

EXAMPLES OF EQUIPMENT USED IN CLASSES

Here are some examples of experimental apparatus talked about online by classes on the social network site during the 2011 project.

Based on the document published by Corinne Laroux on 14 March 2011 at 9.30 p.m.21h30.

To check if there is a spherical object:

Marbles of different sizes (small, medium, large, enormous, etc.) and made of different materials (glass, porcelain, plastic, lead, polystyrene, etc.). We put spherical objects in the control box and tilted it to see if it made the same noise as the mystery box.

To check what is making a noise:

First of all shake each object to see if it makes the same noise as in the box, then put the objects into the box one by one and listen whether it makes the same noise when it is shaken.

To confirm that there are some things heavier than others:

A pair of weighing scales and a number of objects that we guess are in the box.
If we put our hands on each side of the box and tilt it, then we "feel" that the objects do not all fall at the same time. We weigh the mystery box, and then we weigh the control box, adding different objects that we have brought and which we think might be in the box.

To check if there is something which smells:

We think that a clove is stuck to one side of the box because when we smell the box we can only smell it on one side. We will therefore firstly compare the smell of the two items brought with that of the box.
Then we will stick the clove inside the control box, close it and then smell it. We also think that a heavy object is crushing the clove, which makes the smell stronger when we shake the box. We will therefore test if, when we crush the clove, it smells stronger. For this we will compare the smell of an intact clove and a clove crushed with a mortar and pestle. We don't know if the clove is stuck directly in the box or if it is in a small packet or cotton wool, so we will test several hypotheses.

To find out what the string that we can see is for:

We think that the string is holding the object which makes noise in place, so we will attach objects one by one in the control box and compare the sounds.

To check if there is any wood or metal:

A Kapla wooden block, lead marbles, magnets and a metal detector.
We take the magnet, hold the box in the air and hold a magnet underneath it. Then we turn the box over, the objects fall to the bottom and then we remove the magnet. If we hear an object fall, it means that there is a metallic object. We will pass the metal detector over the box, and if it beeps, it means there is metal.
For wood, we will put objects in the control box and a Kapla wooden block, then we will tilt both boxes simultaneously to compare the noise.

To check if there is some cotton wool and a rubber:

We noted that the noise of the objects when they fall onto one side of the box is not the same as on the other side. Something is muffling the sounds. We will test this observation by sticking cotton wool on one side of the control box, then putting objects inside, listening and comparing.
We put the rubber in the box and shake it to compare the noises.

Today we carried out several experiments. Here are our conclusions.
We were able to prove several things.

We know that there is metal, as the metal detector brought in by Maxime beeped at certain parts of the box.
We know that there is iron, because if we put a magnet on the box it remains stuck to the box if we shake it or turn it over. There is iron in a corner of the box, but also underneath the tape used to seal the box. But then we didn't all agree.

We tested, but weren't able to prove that there was a spherical object.
After several tests, one group thought that there was a golf ball, another group thought that there was a small bouncy ball, and finally one group thought that it was a very large glass marble.

About the clove:

Some people packed cloves in a cloth and then stuck it inside, on one side of the control box. Then, they put a golf ball, a Kapla wooden block and a rubber in the box. When they shook the box, they found that the sound was almost the same. The problem was the sound of a small bell: it was impossible to make out whether the mystery object was a small bell from a cat's collar or a small hand bell.
The other group tried a tea infuser, in which the children put cloves: they obtained almost the same sound as in the mystery box.

In any case, our conclusion is that this "game" is very annoying, because we all want to know what is inside!!!

PATHS FOR EVALUATION

The project forms part of the science curriculum and involves working on the investigative process, so the evaluation should be based on this process. It reflects the pupil's progression and allows teachers to adjust their practices. Evaluation should be planned in advance. It may be short and frequent, and must drive forward the learning process. Below are some suggested evaluation approaches, some of which have been used in classes.

1. SKILL EVALUATED:

Identifying equipment suitable for investigating research questions and for testing predictions or hypotheses.

Instruction for pupils:

Choose equipment to test the initial hypothesis.

For example, from the website's blogs (published by Lorenzo Carole on 9 March 2011 and Donati Giancarlo on 24 March 2011)

TO TEST THESE CHARACTERISTICS…

- Prediction A: "metal" type material.
- Prediction B: smell of cloves.
- Prediction C: noise like a small bell.
- Prediction C: a spherical object

…USE THIS EXPERIMENTAL APPARATUS

- We use a magnet. We place it on one side of the box, which we turn upside down and then remove the magnet. If the contents of the box fall down, the magnet has attracted a metal object.
- We take a clove and compare it with the smell from the box. If it is not the same smell, we start the experiment again with other spices (cinnamon, curry, etc.)
- We weigh the full box and then the control box. By subtracting the weight of the empty box from the weight of the full box, we can find the weight of all objects contained within the box.
- We take several objects which make noise, put them in the control box one after the other and compare the noise each one makes with the mystery box.
- We place a stethoscope against the box and listen to the sounds through it. We can hear if there are one or two objects rolling around.

2. SKILL EVALUATED:

Distinguishing what the results and observations show from our interpretations (which can be challenged).

Instruction for pupils:

Record the information from the experiment reports in the columns of the table.

For example: To find ways to describe "objects which roll" in the mystery box according to the noise they produce.

EQUIPMENT	RAW DATA	OBSERVATIONS AND/ OR DEDUCTIONS	INTERPRETATIONS
What I did and what equipment I used...	What I can perceive (sense) and/or measure	What I can deduce directly based on the raw data	What the range of evidence allows me to deduce and/or to explain (compared to my original assumptions)
Research question:			

Alternative: Using the data (in the form of a table, photo, diagram, etc.) or the conclusions from the experiment reports, classify the information under the following headings:

On the basis of the experiment carried out...	
What has been proved and what can be said	What remains to be proved or cannot be said based only on this experiment.

3. SKILL EVALUATED:

From a list of possible ways of investigating the items in the box, pupils are invited to select the one best suited to identifying the object.

Instruction for pupils:

When using a measuring tool, ask yourself why different attempts to take data have given different results. What can you deduce?

4. INVESTIGATION PROCESS SELF-EVALUATION CRID:

Natural Sciences

How to evaluate pupils in science? Grid of observation criteria

From Une didactique pour les sciences expérimentales, A. Giordan Belin 1999.

Pupil's first name:				
Curiosity The pupil gets involved in the proposed activity, asks questions and is motivated.	-	+	++	+++
Creativity The pupil identifies relationships between the problems posed and demonstrates ingenuity.				
Research The pupil ccarries out investigations, considers several options and carries out research.				
Communication The pupil works with his/her classmates, takes their contributions into consideration and collaborates with them to obtain results.				
Self-confidence The pupil spontaneously engages in the activity and is stimulated by the problem posed.				
Critical mind The pupil challenges his/her choices in the event of failure, questions his/her choice of equipment and reviews his/her research methodol-ogy.				
Openness to the environment The pupil shows awareness of his/her environment, taking account of this in the thoughts he/she expresses and the research that he/she plans.				

5. DRAWING SELF-EVALUATION GRID

Level		Yes	No
1	The object drawn is recognisable		
2	The shape of the object is correct		
	Lines are neat and tidy		
	The proportions are correct		
3	The shape of the object is correct		
	Lines are neat and tidy		
	The proportions are correct		
	The drawing is a good size on the page (not too small, not too big)		
	Everything is done in pencil		
	The drawing has: a title and labels		
	Lines to the labels are drawn with a ruler		
	Words are written horizontaly		
	The title is underlined		
	The work is neat		

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