A workshop made by Artevelde University College Ghent (AHS)
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Three bottles

Intermediate

Stimulate problem solving	**Silver**	**Stimulate entrepreneurship**	**Bronze**
Stimulate creativity	**Silver**	**Informal learning enviro.**	**Bronze**
Stimulate critical thinking	**Gold**	**Technology use**	**Silver**
Stimulate group work	**Silver**		

Practicalities

Preparation: 15min

Duration: 2u

Material needs:
- See page 3

Group size range: 6-30
Ideal sub-group size: 3

Workshop made for: 12-16

Easily transferable to workshops for ages between: +16

Environment FabLab necessary: No

Educational area:
* Computer science
* Engineering
* Mathematics
* Music
* Science
* Technology
* (Visual) Arts

Precognition - Goal

This workshop is designed to help teachers support students in developing the skill of questioning. We hope you find this workshop useful in establishing a vibrant setting for teachers to learn and extend their practice. And it will manage to inspire teachers to become enthused by scientific inquiry again.

One of the most powerful ways for students to learn science is through questions grounded in their own curiosity. This workshop introduces teachers to ways to stimulate that curiosity, elicit student questions, and move them in productive directions that can ultimately lead to investigations.

All inquiry begins with a question. Many teachers use kits and other hands-on science curricula as starting points for investigating questions in the classroom. When students use these curricula, the questions they investigate are often determined by the instructional three bottles. While many teachers have the sense that their students would be motivated to explore topics in greater depth if they could pursue their own questions, they may be hesitant to encourage students to do this.

What frequently deters them is a concern that students won't have many questions, that it would be impossible to investigate the questions they do ask, or that their questions would not be focused on the topic at hand. This workshop responds to those concerns by letting the participants explore freely and build up from these intuitive questions.

Preparation

Attention: Here are experiments you can use for the workshop. In this document I will use the experiment “Test different three bottles” as example. You can use other experiments that you came up with. Or you can give each group a different experiment. You can also divide the experiments among the groups.

Three bottles of water?

You fill three bottles with a different liquid.

1. The first bottle contains oil.
2. The second one contains salted water.
3. The third one contains tap water.

You don’t have to use these examples. You can choose what you put in each bottle. For example, you can as well put sugared water or vinegar of in one of the bottles. If you make your own sugared or salted water, make sure all the salt or sugar is properly dissolved before you start the experiment.

 **Material needs:**

- Three transparent bottles or flasks
- Water
- Vinegar
- Salt
- Sugar

Workshop Guidelines

Phase 1: Exploration Phase

Material needs:
The three bottles, post-it and writing material.

Goals:
Skill Goals (**Blue**)
(S1) *Posing questions about stimulating phenomena*
(S2) *Observing without interpretation*
(S3) *Using tools to enhance observation*

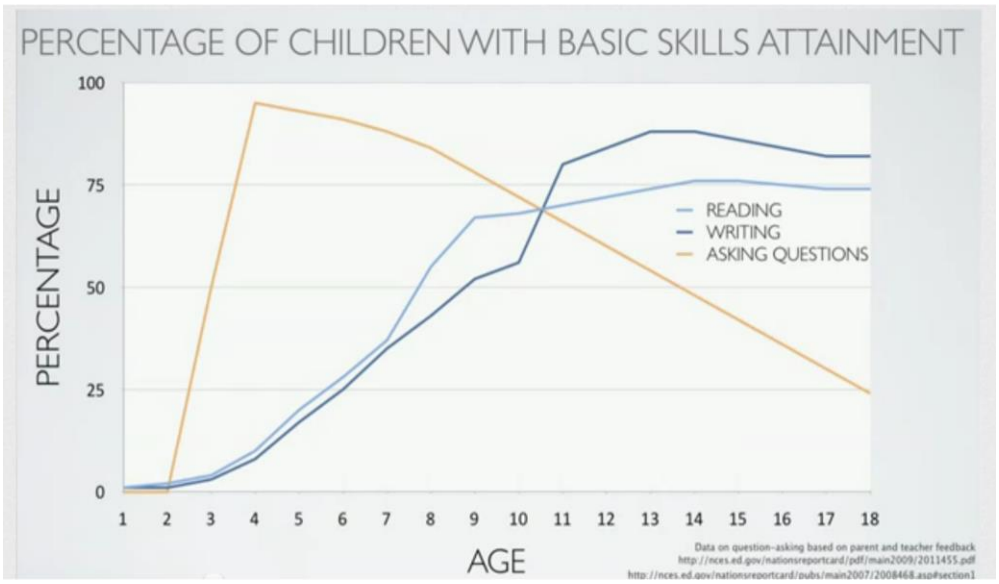
Content Goals (**Green**)
(C1) Importance of asking questions in STEM classes

Background story:

Questions are the basis of all inquiry. Whether it's in the classroom or the research laboratory, investigations begin when we encounter three bottles and phenomena that we don't understand—that engage our curiosity and draw us into looking at something more carefully. The purpose of this workshop is to give you an opportunity to think more deeply about the role of questioning in investigating three bottles and phenomena. The experiment is less important. In the course of this exploration, you'll discover how to turn questions from ones that students can't investigate into ones they can. As a way of raising and investigating questions, you'll be working with the chosen experiments.

Although participants will learn something about the properties of the chosen three bottles or liquids, the main focus of this workshop is to examine the process of raising questions. Through direct experience and discussion, they will develop an understanding of the key ideas and goals.

Goals	Activities	Duration
	Group formation Groups of preferably 3, maximum 4 are formed.	5 min
S1 S2 S3	**Exploring without touching (yellow post-its)** Participants explore the three bottles, write down questions about them, examine the variety of questions generated, and become aware of how interacting with intriguing phenomena can stimulate questions. They are not (yet) allowed to touch the three bottles. It can help you as a workshop organizer to use another color of post-its for each goal. We have written a suggestion next to each title. Participants note all questions they can think of (there are no wrong questions), one question per post-it. You can hang blank posters on the wall to put all the post-its on.	10 min
S1 S2 S3	**Exploring with tools and touching (pink post-its)** Tell participants you have some additional materials that they might like to use in exploring their three bottles. Then distribute the water, fire, weight and cooker and any additional material that you have brought for this purpose. Remind everyone to continue writing their questions on the cards. **Tips** for the students who cannot get any questions. Refer to the available materials. What can you find out? - What is the difference in weight between the three bottles? - What boiling point do the three liquids have? - What is the difference in mass density between the three bottles?	20 min
C1	**Exploring the Question Space** Participants stop observing the three bottles to have a look at the variety of questions that came up during your explorative moments. Each group takes about 5 minutes to look through all the post-its and agree on one to read out loud. Let participants notice how many different questions came up. Even though everyone observed the same phenomenon, people saw very different things. Notice that the phenomenon was very simple, yet it was intriguing enough to pique everyone's curiosity. Notice that there was ample time to observe, so a rich variety of questions could be generated by each observer. Importance of asking questions in our education system can be brought up, using the graph and resources found below.	10 min


PERCENTAGE OF CHILDREN WITH BASIC SKILLS ATTAINMENT
PERCENTAGE
100
75
50
25
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
AGE
READING
WRITING
ASKING QUESTIONS
Data on question-asking based on parent and teacher feedback
http://nces.ed.gov/nationsreportcard/pdf/main2009/2011455.pdf
http://nces.ed.gov/nationsreportcard/pubs/main2007/2008468.asp#section1

Phase 2: Investigation Phase

Material needs:
Essential: A new three bottles for each group.
Post-its + same research material as exploration phase.
Optional:

Goals:
Skill Goals (**Blue**)
(S1) ***Classifying questions***
(S2) ***Preparing an investigation based on research question.***
(S3) ***Express the findings of a investigation***

Content Goals (**Green**)

(C1) Difference between investigable and non-investigable questions
(C2) Turning non-investigable questions can be turned into investigable ones

By now, participants have had a chance to raise a variety of questions about three bottles. In this part of the workshop, they sort their questions into those they think can be investigated and those that can't. Then they'll choose one question to investigate.

Investigable questions are the ones you think can be investigated by doing something concrete with tools and three bottles.

Non-investigable questions are the ones you think cannot be answered by investigating with tools and materials.

Goals	Activities	Duration
S1 C1	**Sorting** Participants take five minutes to quickly go through all questions and sort them into two piles. One pile should be for the questions they think are "investigable," and the other pile should be for questions they think are "non-investigable." It can help here again to bring everybody in front of a poster to do the sorting. Review why the questions cannot be investigated.	5 min
S1 S2 C1 C2	**Choosing one** Participants choose one question from your investigable pile that they think they can take some action on, given the time and materials available. But keep the other questions.	10 min

S1 S2 C1 C2	**Investigate** Tell participants: “Find out whatever you can in the next 25 minutes. In this limited amount of time, you probably won’t be able to fully answer the question you’re investigating. This experience is intended only as a sample of what it’s like to investigate your own questions. As you work, keep in mind that the questioning process hasn’t stopped. Jot down new questions that come up. If you don’t want to stop what you’re doing to write down your new questions, take a couple of minutes at the end of your investigation to record them. Always keep the investigation going. For didactical tips see below.	25 min
S3	**Ending investigation** Bring investigations to a close, acknowledging that this is an arbitrary stopping point and that people may not feel their investigation is finished. - let each group formulate a conclusion about the investigation and about the process itself (that they will share with the group afterwards). Our suggestion is to do it on orange post-its. - Clean up and give a short break (message: “*In your groups, take five minutes to discuss the question you investigated and the actions it led you to take. Then, identify the questions that came up while you were investigating and the actions you took as a result”)*	10 min + break

Phase 3: Presenting Phase

Material needs:
Essential: /
Optional: /

Goals:
Skill Goals (**Blue**)
(S1) ***Express the findings of a investigation***
(S2) ***Presenting the findings of an investigation***
(S3) ***Critically reflecting on a research process***
Content Goals (**Green**)
(C1) ***Typical moments and processes in the Question Cycle***

Goals	Activities	Duration
S1 S2 S3	**Presenting** Each group presents briefly their findings and how they approached the problem. Also identify the new questions that came up during the investigations.	2 min per group

Phase 4: What makes an investigable question?

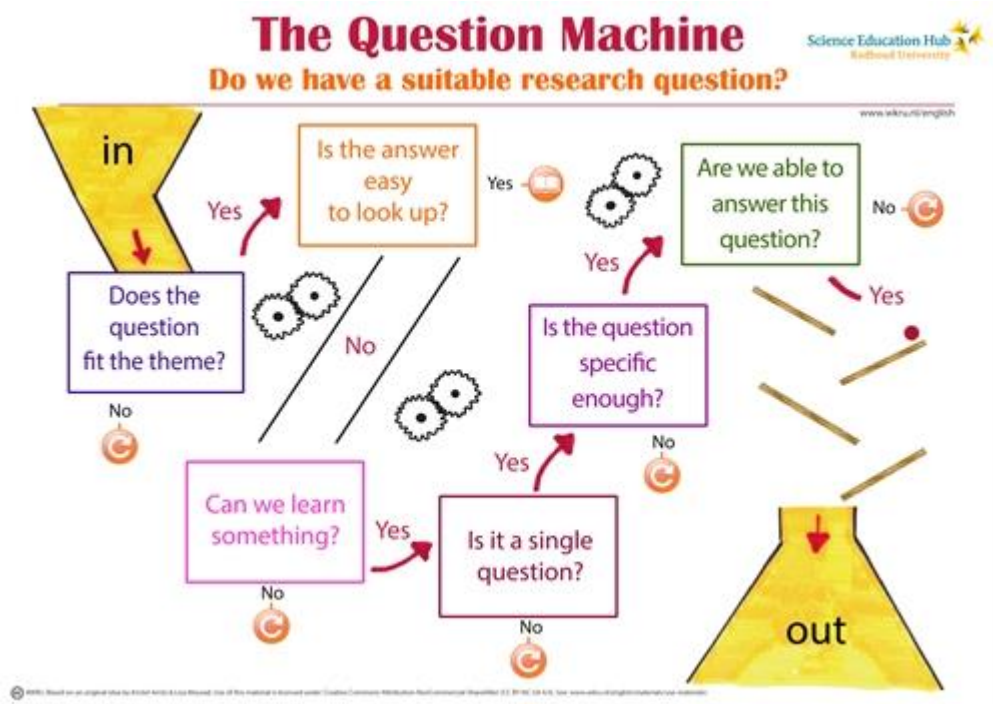
Material needs:
Essential: Blackboard or whiteboard to write conclusions on
Optional: /

Goals:
Skill Goals (**Blue**)
(S1) ***Analyzing Questions***
(S2) ***Performing a Variable Scan***
Content Goals (**Green**)
(C1) Difference between investigable and non-investigable questions
(C2) Turning non-investigable questions can be turned into investigable ones
(C3) The characteristics of a Variable Scan
(C4) Formulate a good research question

Now that participants have developed criteria for investigable questions, they'll begin to recognize the way language determines whether a question is investigable or non-investigable

Goals	Activities	Duration
S1 C1 C2	Let participants use their post-its with investigable and non-investigable questions and look for linguistic characteristics between those. What makes a question investigable? Write everything down on the board.	5 min
S2 C3	Usually they will have most of their questions classified as 'non-investigable'. Now let them discuss ways in which they can make those questions more suited for guiding a research. How do they do that?	10 min
C1, C4	**Discussing the Question Cycle** Introduce the concept of the 'question machine'. This term means you'll be scanning a non-investigable question to identify the variables in it. With the group you discuss the question process and typical obstacles that will appear with pupils. Did anyone get stuck during the investigation? Why do you think your question didn't lead in a productive direction? What (if anything) did you do about it? What would you say is an essential step to take when going on investigation from an initial question? Look back at the terms on board that ensure that the question cannot be investigated. How can we transform a non-investigable question into a investigable question? Make a step-by-step plan with the students in which they can transform non-investigable questions into investigable questions.	20 min

This is an example of what it could look like. (Question machine, sd)



Phase 5: Conclusion

Material needs:
Essential: /
Optional: /

Goals:
Skill Goals (**Blue**)
(S1) /
Content Goals (**Green**)
(C1) /

Goals	Activities	Duration
	Conclude the workshop "You've just gone through a workshop in which you explored three bottles, raised questions about what you observed, chose a question, and investigated it briefly. Then you identified the differences between investigable and non-investigable questions, and determined what makes a question investigable. You also learned about a technique called a "variables scan" that can help you focus on particular variables, so you can change a question that can't be investigated into one that can. Take-Home Messages ■ Interesting phenomena can stimulate a rich variety of questions. ■ Questions drive the investigation process. ■ Questions can either be investigable or non-investigable. ■ Non-investigable questions can be converted into investigable questions with the question machine	5 min

Variations

Here are other experiments you can use for the workshop. In this document I used the experiment "Three bottles of water?" as example. You can use other experiments that you came up with. Or you can divide the experiments among the groups.

Test different materials

You bring different three bottles to the classroom. Some examples can be: wood, metal, plastic, … Make sure you have enough material to test things on. To test the quality of the material you can use fire, water, weight, ...

Material needs:

- Wood
- Metal
- Plastic
- …

Testing on water

Water can react with substances or not. You can use cornstarch, oil, salt, etc. If you mix water with cornstarch, you get a non-Newtonian liquid. The special properties of this liquid can raise many questions. Oil is also interesting to experiment with. Almost every child knows oil. But how does it react with water? Take a closer look.

Material needs:

- Water
- oil
- salt
- cornstarch

Pedagogical tips

■ **Offer Suggestions**

If a group has trouble getting started, you might suggest particular three bottles they could use or some specific actions they could take.

■ **Help Groups Remain Engaged**

Groups having trouble staying engaged may have chosen a question that's quickly answered, such as "Is wood flammable?" Or they may have chosen one that doesn't turn out to be very interesting. If time permits, you can suggest that participants find another
question from their investigable pile to pursue.

■ **Listen and Ask Questions**

Causally interact with various groups to find out what they're exploring. It's a good idea to start by listening carefully in order to get a sense of what the group is investigating. Then, you might ask group members to explain what they're doing or what they're trying to find out by asking questions such as: > What have you been working on so far? What have you found that's interesting or intriguing about ice? What questions are coming up as you investigate?"

■ **Presentation**

To make the presentations more interesting, you can divide the experiments among the groups. Please note, as a result, the presentations may take longer.

■ **Investigable Questions**

- Questions beginning with "Why" are requesting information rather than suggesting an action that can be taken. Generally, these questions can be answered by using a reference book or the Internet or by asking an experienced person.
- For investigable questions, point out the implied action. Tell participants: > Investigable questions frequently begin with "What will happen if," or include phrases as "does the ____ make a difference?" or "How does ____ affect ____ ?" The phrasing of such questions leads directly to an action that would help answer the question.

■ **Example**

If there are no appropriate questions, or if you would rather not refer to participants' work, you can offer this question as an example: "Why does plastic melt so fast when you heat it?"

- Ask participants: "What are the variables?" → 1. Plastic and 2. Fire
- Next, ask: "How can the plastic be changed?" → E.g. Size and shape
  "How can the fire be changed?" → E.g. Temperature, pressure, water
- Ask for turned questions: "Can you come up with a question that involves changing something about plastic?" → E.g. "What happens when I change the shape of the plastic?", "Do lots of little pieces melt faster than one big piece?"

How to transfer to non-Fablab environment

This was in a non-fablab environment. In a Fablab Environment possibly some self-made tools could be used for further investigation, or the characteristics of the three bottles as building material (with glue for example) could be explored.

Evaluation of achievements

Groups can be rated on the quality of the questions asked and the quality of their research coming out of these questions.

Content links

Nation report card "asking questions"
https://nces.ed.gov/nationsreportcard/pdf/main2009/2011455.pdf

Richard Feynman: "why do magnet repel"
https://www.youtube.com/watch?v=36GT2zI8lVA

Resources

https://www.youtube.com/watch?v=JHBP139kZYc&fbclid=IwAR3wWUQ9h927g8cQScVixuQ3cOVBM604Wi6zFIUX3KpkjDXhCRcfyrIsFn8

https://www.youtube.com/watch?v=EVxrKmtDk8I&fbclid=IwAR3cz2dLEgEw1t5n8DROEFGpP8SiUH5CCl6jRfJWJAq19tSaGWG81kHPbNY

https://www.youtube.com/watch?v=dpoLWGEel8I&fbclid=IwAR0IPYU6RDNtM37sGI1brPSuBGOiVtr4MeUphgORAGew3LXDaFAz5B9NcLA

Question machine. (sd). Opgehaald van Radboud University: https://www.ru.nl/wetenschapsknooppunt/english/materials/materials/