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Investigating with Concept Cartoons: Practical suggestions for using concept cartoons to start student investigations in elementary school and beyond

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Abstract

Concept cartoons can be used to diagnose misconceptions and stimulate discussion of basic concepts and phenomena. However, the teacher can also present a cartoon and then ask students to think of experiments to further investigate the phenomenon shown in the cartoon. Our experience is that students from age 9–18 very quickly come with creative ideas and start investigations. That is, of course, only the beginning. The teacher will have to follow the work of the students closely and help them to develop their investigation skills and critical thinking. In the workshop you will experience how to start an investigation with the cartoon and then we will focus on how to use formative assessment to improve the work of students.

Key words: concepts, evidence, reasoning, inquiry, designing experiments, concept cartoons.

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Introduction

Concept cartoons (Naylor & Keogh, 1999, 2012; Naylor et al., 2007) are a popular means to stimulate reasoning with science concepts among children from the age of 8–18. The concept cartoons also provide a natural context for children to design their own experiments rather than do cookbook experiments.

> During my first experience in grade 4 I showed them a glass with cold water and added some ice cubes. They reacted well with observations and experiences. Then I introduced the cartoon (see appendix) and asked them whether they could think of experiments to further investigate the phenomenon. They decided in no time what they were going to do and rushed off to search for beakers and other things they needed. When they were together again, and I asked a few questions, it quickly became obvious to them that their original idea was not good enough and that they had to do some more thinking. They thought more and came up with interesting and meaningful experiments.

Show children a concept cartoon, have some discussion, and then ask them to design an experiment to provide evidence for or against one of the statements in the cartoon, and the children rush off to set up an experiment. They get into the activity so quickly that the teacher even has to slow them down and force them to think through their ideas more carefully and that is where the challenge is, to get them to think and to reason and yet maintain the enthusiasm.

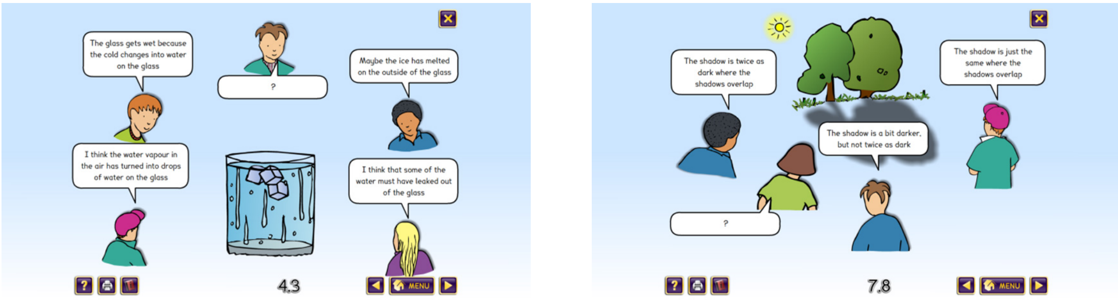
Key objectives of learning science are ***learning to reason with evidence* and *learning to reason with concepts and theories***. For a long time science curricula limited reasoning in elementary science curricula due to boundaries which had emerged from the work of Piaget. However recent studies have shown young children arguing well in advance of curriculum expectations (Tytler & Peterson, 2003). Young children may not be able yet to control variables, but they are capable of reasoning with evidence and concepts to some extent. The questions are what reasoning can they do potentially at their age and to what extent can this be achieved in typical classroom conditions?

Inquiry methods have been promoted for elementary science and technology education since the early 1960s (or even Dewey's time) and recently (Rocard et al., 2007) a strong plea for inquiry science was made at a European level. However, real implementation in the classroom is quite limited in most countries. Textbook science dominates and activities are more likely to be only hands-on than also minds-on. There is a need for inquiry teaching methods which have a lower threshold for teachers, which teachers are confident to start using and which still have the important key features of *reasoning with evidence* and *reasoning with concepts* and *recognizing and understanding different points of view.*

Exactly for that purpose Naylor and Keogh (1998, 1999) introduced first the concept cartoons and later the puppets (Simon et al., 2008). In concept cartoons characters hold incompatible views/claims about an everyday phenomenon. Children then are asked to argue about these claims using their own experiences as "evidence". This is what is mostly done in concept cartoon activities used around the world. **However, one could go one step further and ask children to design experiments to support or falsify statements in the cartoons. Then the cartoons in a very natural way lead to inquiry.**

Naylor et al. (2007) tried concept cartoons with children of age 8 and 9 and found that children were capable of supporting their views with arguments and listening and responding to arguments of others. An analysis scheme of arguments derived from Toulmin did not work, but a simple classification of interactions provided useful information. Children can argue about the cartoons based on their own everyday experiences, most children do use arguments and react to arguments of others and children co-construct arguments in their small groups without teacher support. However, also 18-year olds react well to concept cartoons as Naylor & Keogh point out in their 2012 review of concept cartoon studies.

Although there are many reports of teachers and researchers using concept cartoons to get students to design investigations, we have not yet found research reports except for our own (Berg et al., 2012). This workshop paper is intended to provide practical suggestions for how to use the cartoons to get students and teachers into investigations, based on our experiences in different schools and at different levels (grades 4–6). Some background knowledge on concept cartoons is assumed.



a) b)

Figure 1: a) Condensation, b) Shadows

Preparation for the teacher

1. Choose a cartoon which provides sufficient possibilities for experimenting. Not all cartoons are appropriate. Identify the basic concepts and expected preconceptions and do a little bit of exploring the phenomenon in the cartoon.

   > The condensation cartoon (Figure 1a and see appendix for bigger version) always works very well. The cartoon about whether two overlapping shadows from the same light source are darker or not, did not lead to much creativity. On the other hand, a cartoon we made about skate boards getting off inclined planes spawned a great variety of experiments.

2. Think of some experimental ideas students might come up with and which materials might be needed for that.
3. Always have some extra materials as students might come up with unexpected ideas and we like to stimulate their creativity.
4. What are the key concepts and what are the main process skills you will pay attention while the students are at work? Is it reasoning with evidence, or will you focus on correct measurement this time, or on properly describing design/results/conclusions? In an investigation all of these will occur, but not all can be singled out for special attention. Prioritize and create a learning trajectory across the school year.

5. Make a list of questions the teacher can ask about the concepts and about the experiments. Some questions will be used by the teacher in plenary discussion before and after the activity, other questions will be used while the students are at work and the teacher goes around observing and reacting to the students' work.

The lesson

6. *Whole class.* Getting acquainted with the phenomenon

    Condensation example (appendix): put a glass of cold water from the refrigerator on the table and add some ice cubes. Let children observe, what happens? Do they see the water on the outside? Have they seen something like that before? Are there related experiences (car windows getting foggy, windows when taking a shower)? What are their experiences?

7. *Children individually.* Present the cartoon and let children answer individually on a worksheet whom they agree with and why. See example worksheet in the appendix.
8. *Whole class.* Make an inventory of the different opinions, experiences, and arguments. The teacher leads the discussion and assists students to present their ideas and explanations but remains neutral. The discussion ends with a list of questions which can be asked about the phenomenon.
9. *In small groups.* Divide the students in groups and (if the teacher chooses to) assign roles for cooperative learning. Ask children to think about experiments which can help them to find answers to one of the questions or to further investigate the statements in the cartoon. Let them describe the experiment briefly on the group worksheet (appendix).
10. Some groups have a tendency to right away start experimenting with the first idea that comes up. Try to get them to think a bit deeper about the experiment they propose. Let them fill in the worksheet (appendix) and question them critically. We ourselves usually postpone the actual experiments to the next lesson. There are two reasons for this: 1) we want the students to think deeper about what they are going to do, 2) students can list what equipment/materials they need and bring that to class next time. With some cartoons, for example those about falling motion, it is not feasible to postpone the actual experiments but with most cartoons the split in a preparation lesson and an experimental lesson works quite well.

    Grade 5: With a cartoon on bungee jumping in which the characters wondered whether heavy people would fall faster and farther, the children thought of building towers of lego or blocks, using rubber bands of equal lengths, and comparing a full water bottle (heavy person) with a half filled bottle (light person). Then they were going to do a fair comparison. One girl emphasized that the rubber bands for the heavy and the light bottle should be exactly equal length.

11. *Next lesson in small groups:* students carry out their experiments.
12. *In groups.* In elementary school the children probably have little experience in describing the set-up and results of their experiments. A worksheet helps to

give structure. Michael Klentschy (2008) developed a notebook method where children from 6–14 develop their skills in documenting their reasoning from expectation to observation and conclusion. His book shows nice examples of progression across the ages and this method has positive results both for science and language skills of students.

13. *Whole class.* Presentation of results during which other students and the teacher can ask critical questions. The two leading questions are: a) what have we learned about the phenomenon (e.g. condensation) and what is our evidence for that? And b) what did we learn about experimenting and doing research? To let all groups make oral presentations can be too time-consuming unless the teacher wants to practice oral presentation skills. Instead the teacher can lead a discussion about the two main questions in which the students introduce their evidence and reasoning.
14. Assist the class in the interpretation of research results after all groups have presented and then link back to the preconceptions at the start and point out what the class has now learned from the experiments. And certainly some new questions will come up.

Experiences and solving problems when teaching with concept cartoons

The try-out of concept cartoons generates a lot of enthusiasm and is usually successful. However, we also ran into problems for which we constructed solutions which have been tested in the classroom. The following points show both problems and solutions.

Designing experiments. Children are creative in thinking of experiments. When there are more variables, children have trouble to limit themselves to manipulate only one of these variables.

> When we asked how the melting of ice could be accelerated, they wanted to change everything to get the fastest melting while we wanted them to investigate the variables one by one. With some clever guidance this can be solved.

Quite frequently the research question and the proposed experiment do not fit.

> With the condensation cartoon one group claimed that water vapor from the air would condense on the outside of the glass. However, in their experiment they proposed to fill their glass with coca cola. So as if they wanted to investigate whether condensation also happens with other liquids than water.

If you do investigate this, it turns out that every liquid will work as long as the temperature is lower than that of the air. Water and water-based liquids such as Coca-Cola do particularly well as the specific heat of water is high and it takes a long time before the liquid reaches room temperature.

Predicting with reasons. Children can predict quite well but they cannot formulate their reasons well on paper and it helps if the teacher questions them and looks critically at their formulations. Obviously the skill of predicting and supporting the prediction with reasons requires a long learning trajectory.

Classroom management and cooperative learning. We usually use groups of 3. In every group one student is responsible for any communication with the teacher, one takes care of the equipment, and a third is responsible for good reporting. This prevents the problem that 30 children would line up for assistance of the teacher. In the next activity children get assigned to a different role. The roles are based on the Australian Primary Connections program (2008).

Designing en executing experiments. Children think of an experiment and too quickly get on with it. This can be prevented by doing the designing in one shorter lesson and the executing and reporting in the next and longer lesson. However, in the design lesson it is helpful to have some of the experimental materials in the room to help children in thinking about the design of their experiments. With the cartoon about falling motion, it will be difficult to stop children from trying out immediately, but do force them to think about what they are doing.

Executing experiments (1): Some children are busy reasoning and then conduct their experiment only once. Others go through many repetitions. With questions like *"How can you be sure of your results?"* you can let children think about the power of their experimental proof and how this could be enhanced by repetition or varying conditions.

Executing experiments (2): During the experiment children often change so many things that their experimental set-up no longer matches with the research question they started with. Of course there will be (and should be) improvements as they get more experience with their experiment, but they should not forget their main research question. The set-up of the worksheet (appendix) helps with that.

Final presentation: Groups of 4th grade children right away applauded their class mates when presenting instead of having a critical discussion. Solution: let children from the audience give a *'tip'* and a *'top'*. The *tip* is a suggestion for improvement. The *top* is about something the presenting group has done well. Even better is to let the audience indicate what they learned from the presentation that they did not know before. Of course one could also opt not to have final presentations by the groups but instead to have a post-lab discussion where all can contribute and the teacher keeps a clear focus.

In the post-lab discussion there are two central questions: a) *What did the group learn about the phenomenon and the major concepts?* and b) *what did the group learn about investigation/research.* At the end of the discussion, the teacher summarizes the answers to these two questions.

Worksheet or notebook: Carefully choose priorities for written reporting.

> In one group with selected talented grade 4 students we had a very ambitious worksheet where children had to predict, provide arguments, reason with those arguments and answer other questions about the experiment they were going to do. Our elaborate worksheet killed the motivation.

So carefully select priorities and keep the writing limited as in the example worksheet.

To conclude an interesting experience:

> Four talented grade 4 children (age 10–11) experimented with condensation (see cartoon in the appendix).Their first hypothesis was that the outside of the glass could only get wet inside the refrigerator. But in their first experiment with a glass that was dried on the outside, water

still formed. Their second hypothesis was that the condensation water would come out of the glass. They put on a lid and predicted the outside would remain dry. However, it still became wet. They went through a series of experiments and discussions of everyday experience with windows fogging up. They observed that with hot water in the glass, the inside would get foggy. I demonstrated to them that my breath also creates water on the outside of a glass filled with water of room temperature. Then Emma made the big jump. She said that water vapor will form liquid water when it hits a colder surface. When asked how to test this, she suggested that if the water temperature in the glass would be above 37 degrees, then our breath would not form water on the glass. And she was right!

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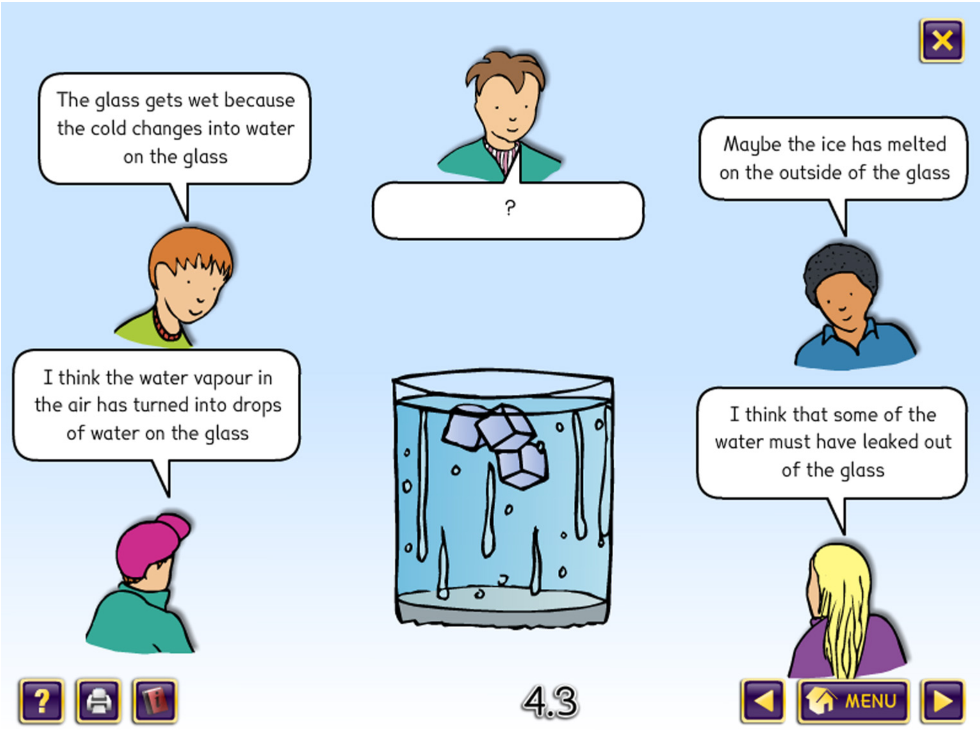
Appendix: Example worksheets ICPE Prague August 2013

Wet Glasses

Worksheet 1 Individual

Name: ______________________________________

A glass of water from the refrigerator with some ice cubes is put on the table. The outside of the glass becomes wet.



1) Who do you agree with? Why do you think so?

2) Could it be that one of the others is right? Explain.

Workheet 2 Group

With your group think of an experiment to further investigate the phenomenon in the cartoon or to collect evidence for or against one of the statements in the cartoon.

What is your research question?

What do you expect as an answer?

How are you going to do the experiment? (make a sketch)

What do you think will happen?

What do you need for the experiment?

How will you record the observations/measurements?

Worksheet 3: Group or individual

Remember, what did you expect?

What did you measure or observe?

How is that different from what you expected?

How do you explain what happened?

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