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Onderzoekend leren met concept cartoons in de basisschool[1]

Getting children to design experiments through concept cartoons

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Abstract

Concept cartoons (Naylor & Keogh, 1999; 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. 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. In our research we tried out concept cartoons experiments in grade 5 (age 11) and we describe some of the typical difficulties children have in making a claim, designing an experiment, and using the results to reconsider their claim.

Keywords: concepts, evidence, reasoning, inquiry, designing experiments, concept cartoons

Introduction

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 rather 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

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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.
Chin and Teou (2009) used concept cartoons in 5th and 6th grade classes in Singapore. Their aim was to use concept cartoons as assessment for *diagnosing their misconceptions and designing learning interactions to engender conceptual change*. The cartoons and subsequent discussions of children clearly enabled the teacher to assess children conceptions in the discussion and adjust the lessons accordingly.

Research questions

Can concept cartoons function as a low threshold tool to trigger reasoning with evidence and reasoning with concepts in Dutch schools? Our very first try was encouraging, but also showed some problems. Within minutes of posing the problem of condensation on the outside of a glass with water and ice cubes (figure 2), children aged 8 – 9 rushed off to get the things they would need for an experiment to test one of the claims in the concept cartoon. In a minute they had thought of something and they immediately wanted to implement. When we got them together again and to think a bit deeper, they did come up with meaningful experiments. So our first rule became one session arguing, thinking, preparing for an experiment and in another lesson execution of the experiments. Since then we have experimented in 4 schools in grades 4 – 6 and some teachers from other schools have tried as well. In this paper we will outline what we learned in our last series of experiments in a grade 5 class.

1. Can cartoons function as low threshold tools to get children to design their own experiments?
2. Does this process lead to reasoning with concepts and evidence?
3. Which problems do students have in reasoning with evidence, or, specifically with designing and executing experiments and drawing conclusions? Which suggestions can be given to the teacher to obtain maximum results with respect to reasoning with evidence and concepts?

Methods and samples

Three different cartoons were used in a heterogeneous grade 5 class with 29 children (aged 10-11). The children had little or no experience in inquiry based learning and doing experiments, nor had the teacher. They did have some knowledge of science concepts, because of a textbook they used once a week. Actually, the textbook had many activities, but these were not used in the science lessons.
We planned six lessons in which three concept cartoons were introduced. Our main questions were: do the cartoons lead to reasoning and can children develop experiments to test their claims?
For each cartoon there were two lessons and the steps followed in the lessons were as follows:
Lesson 1 (one hour):

1. The teacher handed out the cartoons with a short introduction to make sure the children understood the concept and cartoon.
2. Children individually were asked to write down their own opinion about which cartoon character was right or had the most plausible answer and the reason for their choice.

3. The children were then put in groups of 4 (sometimes 3 or 5) and were asked to discuss their claims and reasons as a group. Roles were assigned such as writer, manager, presenter, and liaison to the teacher (see description later on).
4. Next they were asked to design an experiment to test one of the statements in the cartoon, this could be to proof it wrong or to support it. The group was asked to describe their experiment on a worksheet with pre-formulated questions (figure 19), to draw a sketch of the experimental set-up, to write what they expect ed as outcomes, and to make a list of needed materials.

Lesson 2 (one hour):

5. The groups of children conducted their experiments and formulated results.
6. The groups presented results to their classmates.

The teacher selected the cartoons: 1) condensation on the outside of a glass with cold water and ice (figure 2), 2)shadows *is a double shadow darker than a single one?* (figure 8), and 3) skate boards on a slope (figure 5). In hindsight we should have selected series of related cartoons to have a better chance of learning and reinforcing concepts, but it was important to get ownership of the teacher.

The lessons were observed by two researchers (Kruit & Wu) and guided by the teacher with assistance of one of the researchers (Kruit). The observers took notes and wrote reports about the lessons. Children wrote their initial claims and arguments on individual worksheets. The individual and group worksheets were analyzed to determine first their individual choice/claim and their supporting argument. The subsequent choice of the group and the argument were written on a group worksheet after the group discussion. During the lessons three out of the 7 groups of children were filmed and audiotaped. In short our data consisted of individual and group worksheets, video and audiotaped transcribed discussions and unstructured lesson observations by two of the experimenters (Kruit & Wu).

Results and discussion

The concept cartoons are a practical strategy for use in the science classroom. They need little introduction, they keep children on task, they can stimulate high level discussion, they help to minimize classroom management problems and they can stimulate children to collect evidence by designing experiments (Naylor & Keogh, 2012). In their studies Naylor and Keogh found that children were engaged in deep discussions for long periods of time (Naylor et al, 2007). In this section we will give examples of how the cartoons indeed functioned as a low threshold trigger for designing experiments and how the cartoons and experiments led to reasoning. Next we will formulate the problems we ran into and where intervention from the teacher could be helpful to get the children to a higher level of reasoning with evidence. We can look at teacher intervention is two ways: the general set-up of a class and classroom management, and teacher intervention and feedback with small groups, for example asking the right questions at the right time.

We introduced the concept cartoons in grade 5, age 10-11. Our basic assumption was that children at that age would have the vocabulary and verbal and writing skills to express their thoughts, make an argument and write it down. In other studies it was found that younger children were able to co-construct arguments with teacher intervention, but claims and data were superficial and generally not backed up with evidence (Keogh et al., 2003; Naylor, Keogh & Downing, 2007).

<u>Designing and doing experiments</u>

After writing down their group claim (Lesson 1, step 4), the children were asked to design an experiment to collect evidence for their arguments. They had to think about the material they needed and were asked to formulate the experiment in words as well as a drawing. They were also asked to describe it such that other groups would be able to replicate the experiment. In the next lesson they were provided with the material they had written in their planning sheet and then they conducted the experiment.

The children in general were very enthusiastic about designing an experiment. However, the level of designs differed among groups. In some cases the children replicated the experiment shown in the cartoon, in other cases the children did come up with changing one variable. Hardly any group experimented with different variables and no group thought of doing a control experiment. For instance children would merely copy the experiment shown in the concept cartoon about the overlap of shadows of two trees, using two books and a lamp to imitate the sun and two trees (figure 1).

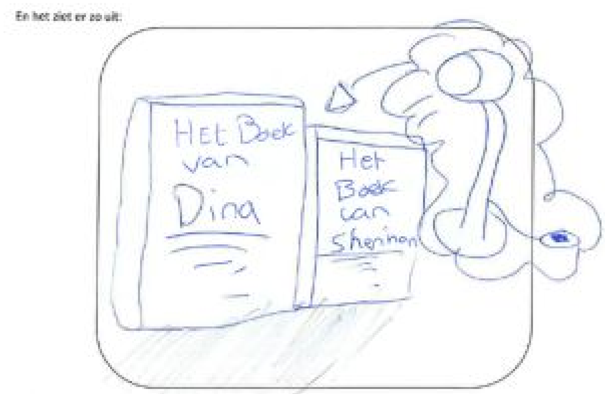


Figure 1 Use of a lamp (the sun) and two books to create overlapping shadows

In the next example (figures 2 and 3) the children copied the experiment shown in the cartoon (figure 2), varying only the type of liquid. They did not make an argument about the influence of the type of liquid; however, they designed an experiment in which they wanted to see if cold cola would have the same effect on condensation as cold water (figure 4). When asked if their experiment worked, so as to come up with evidence for their claim, they noted it did not, so they realized. It seems they were unable to design an experiment that would test their initial claim, but they did explore the phenomenon further …. Would it happen to cola?

The variation of experiments differed between the concept cartoons. When introducing Two Trees about shadow, there was little variation between groups. There was even some intervention needed from the teacher to get the children to test more than just the overlap, for instance they did not come up with the idea to use colored things or different light sources. In the case of the concept cartoon about friction (figure 5) the children designed a wide variety of experiments. For example, one group designed an experiment to measure the distance a marble would roll when coming from a smooth, steep hill. They used a gutter to imitate a hill. Another group designed an experiment to see if a toy car would roll farther on fake grass or on fake asphalt. They did not vary the steepness of the hill. Yet another group intended to try and slow down a toy car with a balloon attached to the car.

Some cartoons proved to elicit discussion, whereas other cartoons were very inspirational in designing experiments. This is important information for a teacher. It helps to have already some materials for experiments on display as we noticed with grade 4 children. Children with little experience in designing experiments are more motivated and inspired when some materials are visible. The teacher can trigger ideas just by offering particular material. For instance, without providing a thermometer or a light sensor the children do not come up with the idea to measure temperature differences when melting ice cubes or to see if shadows are different by measuring different light intensities. On the other hand, when the teacher wants to emphasize reasoning skills in a discussion, the presence of the material can be distracting.

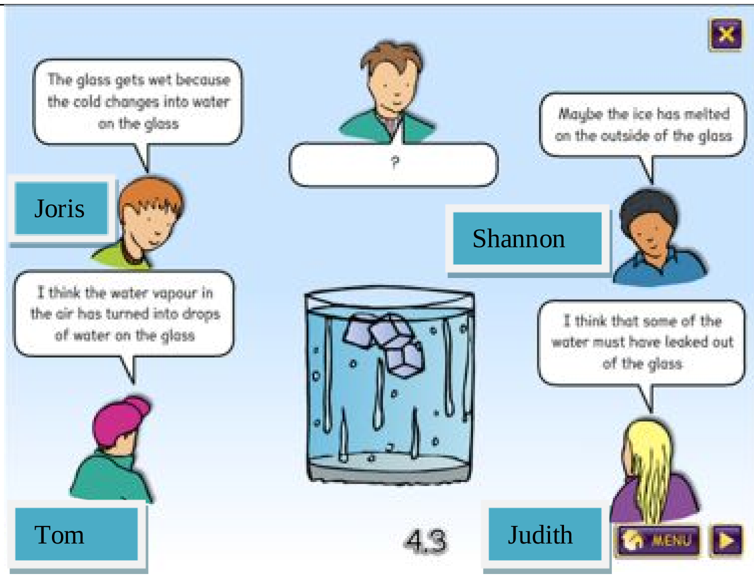


Figure 2 Condensation

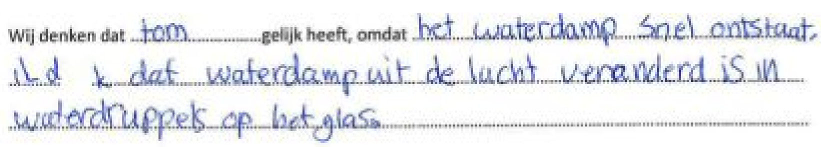


Figure 3 Group claim

We think that Tom is right, because the water vapor appears quickly, I think that water vapor from the air has changed into water drops on the glass

Figure 4 The glass with condensation, ice cubes, cola and a thermometer

Another way to improve enthusiasm and variation in designing experiments is to make it into a contest. In a grade 4 group the children were asked to design an experiment in which they had to use everything they could to melt an ice cube as quickly as possible. The concept cartoon itself showed a large ice cube and a small ice cube and the question was which ice cube would melt the fastest. To prevent the situation in which every group would just be watching two ice cubes melting, we wanted to see with what variables they would come up with. This method proved to be very inspiring and the children came up with a large variety of variables, like using sunlight, lamps, their body warmth, crunching the cubes in smaller pieces, etc. (see figure 6 and 7). One group even tried to slow down the melting process.

Reasoning with evidence and putting it into words

We wanted to see if children not only would be able to design experiments, but would also use the evidence to support or rebut their claim. In 12 of the 17 written group conclusions on worksheets (4 group reports were missing, there should have been 3 cartoon reports x 7 groups) the groups did reflect on the initial claim and used the data to rebut or support their claim. We will describe some examples of how the children used the evidence from the experiments to support or rebut their claims.

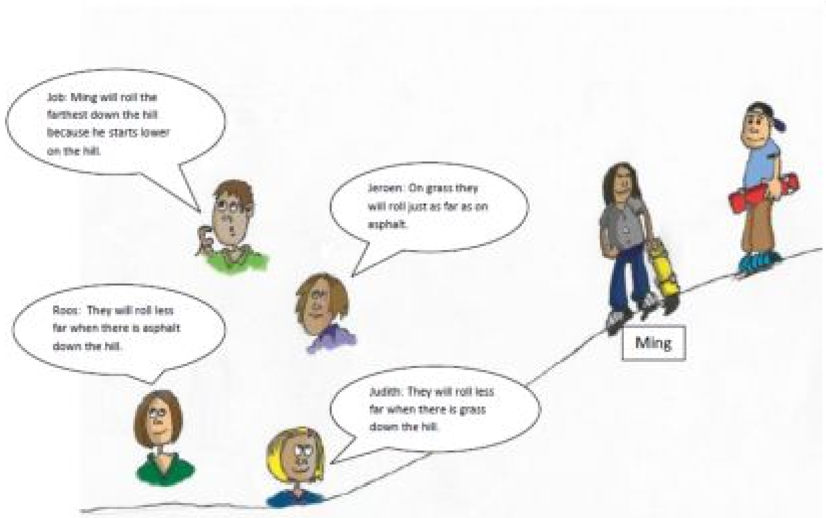


Figure 5 Concept cartoon on friction

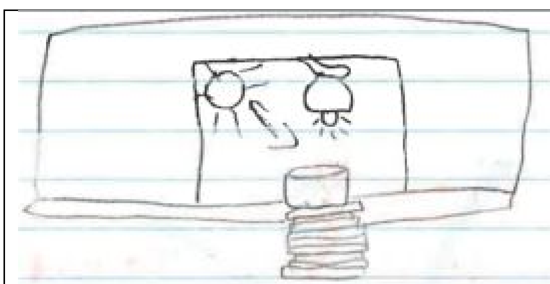


Figure 6 Group experiment melting ice cubes with sunlight and a lamp

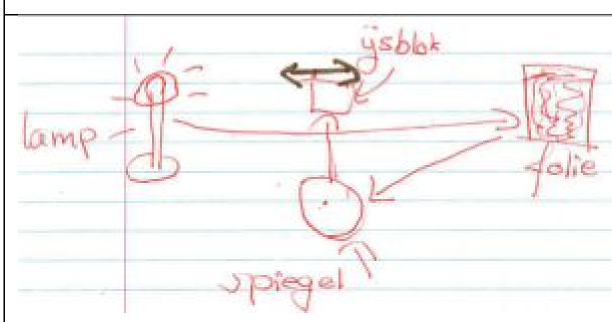


Figure 7 Group experiment melting ice cubes with a lamp and the reflection

In the following example the children had designed an experiment (figure 9) about shadows triggered by the cartoon Two Trees (shadows, figure 8). They wanted to find out if the color of the shadow changes when the light source has a color and also if the shadows overlap, whether it would be a darker shadow:

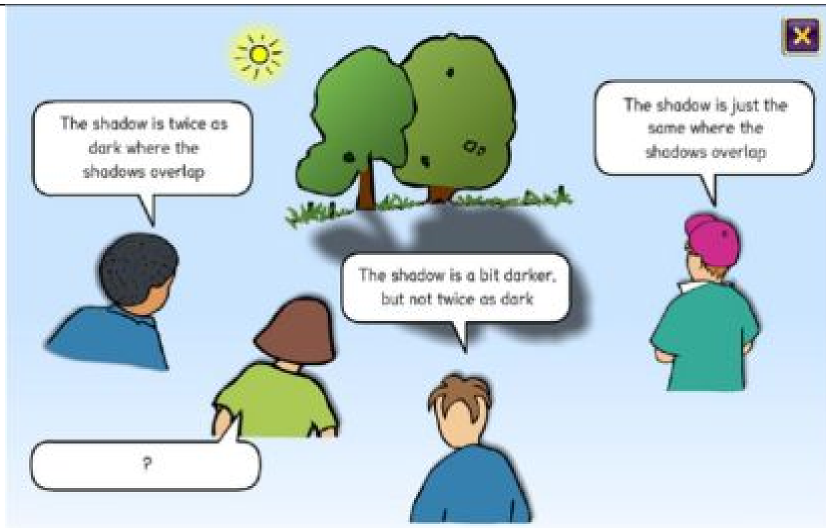


Figure 8 Two trees and shadow

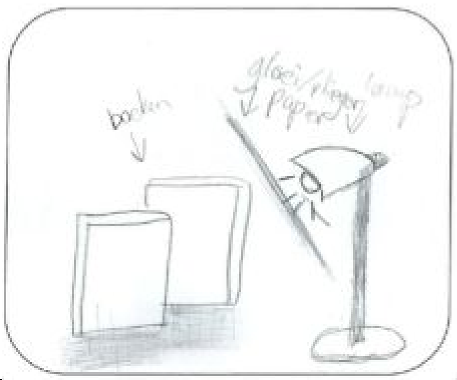
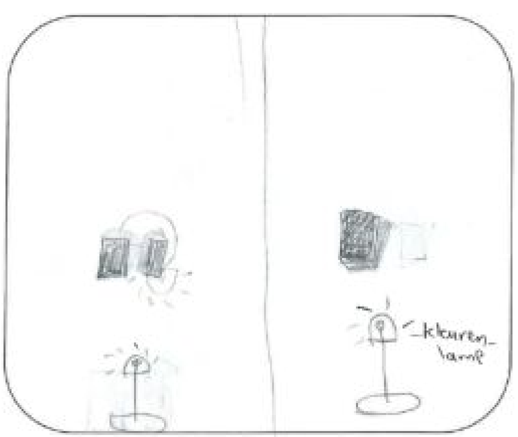


Figure 9 A lamp (sun) and two books (the trees)

The children concluded that shadows are not darker when overlapping and that the color of the light has no influence on the color of the shadow. Another group stated that Frits (left character in the Dutch version of the cartoon) was right, because the sun can come anywhere except behind the trees and that that is the reason the shadow is darker there. They then designed an experiment (figure 10). They wrote the following conclusion: The shadow does not get darker and Jan (right character) is right. They did collect evidence from their experiment and used the evidence to rebut their original claim. From these examples we can see that children are indeed capable of designing experiments and using their findings to support or rebut their claim.



There were some problems when executing the experiments and interpreting the data. Some groups designed an experiment on Wednesday, but changed it when doing the experiment on Friday without writing down the changes or thinking about their predicted outcomes.

Figure 10 Experiment with a white lamp and a colored lamp

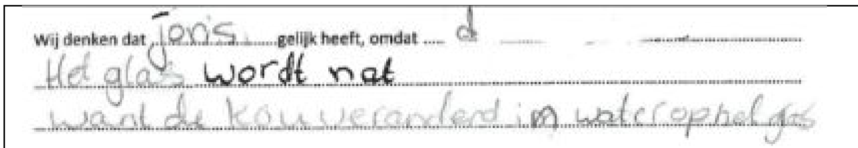
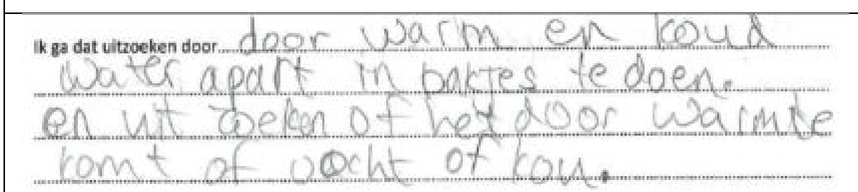
In one example the group claim was that it would make no difference using 1 or 2 books, the shadows would be equally dark. The group designed the experiment in figure 11. However, they wrote in their conclusion that they had observed that it does not make a difference if the light is colored. The children wrote that the shadow of white light has the same color as the shadow of colored light. Clearly they changed their experiment along the way and their conclusion does not refer to their claim. The children did use the evidence of the experiment to make a (new) statement. Another group designed an experiment (figure 13) to collect evidence for their claim (figure 12).

En het ziet er zo uit:  Wij gaan dat uitzoeken door We zetten twee boeken voor elkaar met een lamp, en kijken of de schaduwen even donker zijn.	Figure 11 Experimental set-up shadows *We will put two books in front of each other and see if the shadows are equally dark.*
Wij denken dat Jan gelijk heeft, omdat er maar een zon is dus wij verwachten dat hij niet zomaar donkerder kan worden	Figure 12 Claim *We think that Jan is right (right character in the cartoon), because there is only one sun and so we expect that it cannot just get darker*
Wij gaan dat uitzoeken door 2 voorwerpen en een lamp te nemen eerst zetten en te kijken of het donkerder word	Figure 13 Description of the experiment *We will find out by two objects and one lamp and see if it is darker*
Waar zijn jullie achter gekomen door het uitvoeren van het experiment? 1. dat 2 schaduwen samen niet donkerder worden 2. dat je geen schaduw ziet op zwarte ondergrond 3. dat als je het lichtje heel dicht bij het voorwerp houdt is er geen schaduw	Figure 14 Findings of the experiments *What did you find out by doing the experiment?* 1. *That 2 shadows do not get darker together* 2. *That you don't see shadow on a black background* 3. *That when you hold the light very close to the object, there is no shadow*

In the process of doing the experiments, they started to test different things. They did more experiments than they described in their worksheet, as can be seen from their findings in figure 14. They did draw conclusions from their experiments and learned more about the phenomenon, but there was no connection between their experiments and their initial claim about the sun (or the shadow?) not just becoming darker by itself.

In 4 of the 7 groups the description of the results of their experiments on the worksheets and actions in the classroom on videotape when testing shadows were different: the children did not carry out the experiments as they had planned. That was also the case with the cartoon about condensation (1 out of 6 groups); and the cartoon about friction (2 out of 6 groups). When doing the experiments, the children changed their variables or materials. They failed to write this down. In our study, the children had no prior experience with worksheets. When introducing worksheets in science lessons, the teacher may want to guide the children in writing notes. In the enthusiasm of teaching hands-on lessons, trivial rules for enforcing some basics like writing proper notes and handing in worksheets are sometimes forgotten.

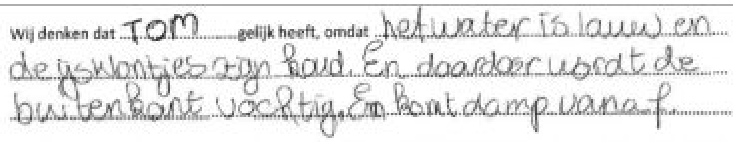
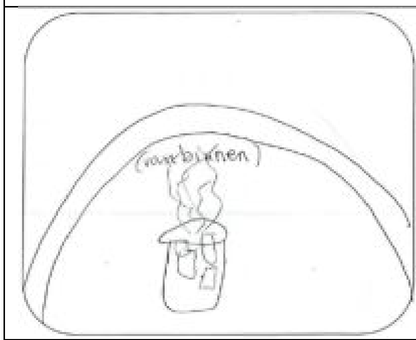
Another difficulty is that the children do not always understand how they should interpret their findings. For example, with the condensation cartoon (figure 2) a group of children wanted to test if the cold was the cause of condensation or the water in the air. Their group claim was that Joris is right: the glass becomes wet because the cold changes into water on the glass (figure 15).

 Wij denken dat Joris gelijk heeft, omdat ... Het glas wordt nat want de kou veranderd in water op het glas	Figure 15 Group claim *We think Joris (left up corner character) is right, because the glass becomes wet because the cold changes into water in the glass*
 Ik ga dat uitzoeken door door warm en koud water apart in bakjes te doen. en uit zoeken of het door warmte komt of vocht of kou.	Figure 16 Set-up experiment *I am going to find out by doing warm and cold water in separate cups and find out if the cause is heat or moisture or cold*

They designed an experiment where they filled two glasses with water, one warm and one cold (figure 16). They wanted to observe where condensation would take place. They noted that only the glass with cold water had condensation and their conclusion was that cold causes condensation. They failed to realize that they still did not know whether cold or water vapor turns into water. Is cold a substance or can it turn into one? The 5th grader cannot be blamed for not knowing and not distinguishing.

Another example is an experiment where the children claim that the glass is wet because of the vapor from the water (figure 17). They intended to collect evidence of vapor originating from the water in the glass by designing an experiment where the children put a glass bowl as a dome over the glass (figure 18). The children described in their results that they saw that de bowl was wet on the inside and so the vapor comes from the water and they stated in their conclusion that they were right about their claim.

However, they did not realize that they do not have proof whether the vapor comes from the air, or that vapor comes from the water (and maybe causes the air to be moist, so implicitly they were right). They should still have done an experiment with a lid on the glass to distinguish between water vapor coming from water in the glass and water vapor already contained in the air.

 Wij denken dat TOM gelijk heeft, omdat het water is lauw en de ysklontjes zyn koud. En daardoor wordt de buitenkant vochtig. En komt damp vanaf.	Figure 17 Group claim *We think Tom (left corner down character) is right, because the water is lukewarm and the ice cubes are cold. And because of that the outside gets damp. And vapor comes out.*
	Figure 18 Set-up of experiment where children put a bowl as a dome over the glass.

The children did design experiments with much enthusiasm. However, they struggled with writing down their design and conclusions on the worksheet. Children do not yet have the science vocabulary, or they are not used to formulate what they think, or they see the writing as a distraction from the more exciting things like discussing and doing experiments. However, writing skills and learning science vocabulary are essential in learning science. The children would probably be able to do better with teacher intervention. When designing a methodology for using worksheets in concept cartoon lessons, the teacher can at first take the role as Writer and pay attention to the different aspects of writing in the worksheets and gradually hand the Writer role over to the children. And then –of course- the teacher will have to provide feedback on what the children write.

The role of the teacher and using worksheets

In this case study both the children and the teacher had no experience with working with concept cartoons and inquiry based learning. On several levels teacher intervention may improve the inquiry and reasoning skills of the children.

In their studies Keogh and Naylor did not report on additional classroom management rules for concept cartoon discussions except for group size. Chin & Teou (2009) did include some ground rules. Based on trials in a heterogeneous Grade 4 and in several groups of gifted children of age 9 - 10 of three different schools we formulated some ground rules for group work which we used in this study with grade 5 children. We made groups consisting of 4-5 children and told them to divide the following roles: Writer (responsible for writing the findings of the group in the notebook), Manager (responsible for collecting and returning equipment), Presenter (responsible for the presentation of results) and Speaker (responsible for asking the teacher for help) (Primary Connections, 2008). In a class with 29 student divided in 7 groups, the possible chaos was reduced, for example: only seven children were allowed to ask the teacher questions, in that way the teacher was able to pay more attention to classroom management and help groups with their progress. When working in groups it can be helpful to use cooperative learning and assign roles to children. That way, every child is responsible for a joint outcome and the teacher can spent more time on substance and less on class management.

External factors can have a large influence on the working atmosphere. For example, in one Friday lesson the children knew they would receive their mid-year school report card at the end of the day. They were anxious and less focused on doing the experiments. The class as a group was tumultuous and it took more effort from the substitute teacher (their usual teacher had the day off) to keep them on task. We also noticed that at times communication in some groups did not go very well, due to fights between the children about different issues earlier in the day.

In several transcripts we highlited in yellow parts that revealed conceptual reasoning of children. In two transcripts these were exactly the parts where a researcher interacted with a group. In the Naylor et al (2007) study teacher interruptions disrupted group discussions. In our case teacher and researcher interactions were important to keep children on task and stimulate conceptual reasoning.

Klentschy (2008) showed that using notebooks has an added value in the science classroom. There are multiple reasons to use notebooks: they have proven to be a good record of what science content is learned by the children and they provide an assessment tool and a feedback tool for teachers. The act of writing enhances thinking by demanding that the child organizes information, therefore providing the opportunity for children to develop deeper conceptual understanding of science. For researchers notebooks can be a tool to analyze reasoning skills and concept development.

In the study by Chin (2009) a discussion template was used to provide structured guidance for small-group discussions and it also required the children to record their reasons for agreeing or disagreeing with the respective cartoon characters. Also a more open template was used to guide the discussion in the group. However, a disadvantage of the tool was that the children spent a lot of time in writing, which could have been spent in talking in the group (Chin & Teou, 2009).

As we only had 6 lessons, we could not follow Klentschy's notebook method but we could use worksheets with the same emphasis on claim, observations, and conclusions. In one of our earlier trials gifted grade 4 children, age 9-10, were struggling to formulate their findings and lost their initial enthusiasm for the science phenomenon and the experiments. With that experience in mind, we designed a more basic worksheet that consisted of the following questions (figure 19).

As noted before, we used three different concept cartoons and each cartoon was introduced in two lessons, one on a Wednesday to discuss the cartoon and design an experiment and one on Friday to carry out the experiment and report the findings.

In the lessons on the Wednesdays the children readily participated in de discussions in their groups. The student with the Writer role was aware of his/her task to formulate their group outcome and arguments. However, the pressure of having to write something down did also have an inhibiting effect. In the following example of a group discussion when being introduced to the cartoon about condensation (figure 2) it is apparent that discussion is guided by the fact they had to put their arguments in written text (figure 20).

The children let their discussion be dictated by the fact they had to write down their arguments. They did not take the time to discuss their thoughts first. It seems that one child already has an argument and is trying to formulate the argument while the other children try to support his writing. In the individual reports of the children in this particular group, indeed this argument ended up in the group report as seen in the example of figure 21.

N.B. In the original worksheet more space is provided for writing and for drawing the experimental set-up Now look at the cartoon together. Discuss the statements of Joris, Shannon, Tom and Judith. Who do you think is right? Why do you think so? *We think that……….is right because……………* Set-up and design: use words and a drawing to describe how you will conduct your experiment. Formulate it in a way that other children can replicate your experiment. *We will find out by…….* What do you expect to happen? *My experiment worked if I observe that…………….* Material: What do I need to conduct the experiment? Make a list of all the material you need. Results: Describe what happened when you conducted the experiment: what did you see? What did you measure*? I saw that…………………………* Conclusion: Read again what you wrote at step 3. What did you find out doing this experiment? Did you expect this outcome? *Yes/no, because…………………..* Discussion: Did things go wrong during the experiment? What things? What would you like to find out more about? *I wonder if…….*

Figure 19 Group worksheet

LL1 Then drops will appear on the glass. LL2 Yes. LL1 Will it not? LL# That's right. LL2 Because… again uh… LL4 Because it will become again..uh (…) become transparent. LL2 Yes. LL2 So in a warm house LL3 Okay. LL1 In a warm house LL2 Is water vapor, but that cools and becomes water with a cold glass. LL1 In a warm LL4 Immer, do all of us now have to write down what you told us?	LL1 In a warm LL2 No, only… LL4 What should we write? LL1 In a warm house LL2 No, in a warm house LL2 In a warm house is water vapor LL3 House… LL& Wa-ter-va-por… LL1 And go on. LL3 I cannot write, I do not have enough space. LL2 If LL1 Look, there is space! LL3 Yo, friend, I am not going to write like that. LL4Haha LL2 And if… LL4 It is water vapor, and?

Figure 20 Group discussion

Another example is seen in a group where one student is sure about his arguments and tries to explain to the other children why he is right. He is also the Writer and uses his power to write down his claim, without taking into account the opinion of his group members (figure 22 and 23).

Group claim	Individual claims (written on an individual sheet prior to the group discussion)
Tom, in a warm house is water vapor and when that touches a cold glass, it will become water drops.	Oliver: Tom, because the cold air coming from the water changes in dew drops.
	Jari: Tom, I think it sounds logical.
	Immer: Tom, in a warm house is water vapor and when that becomes cold, it will become a liquid.
	Daan C.: Joris, I find it logical

Figure 21 Individual claims in relation to group claim

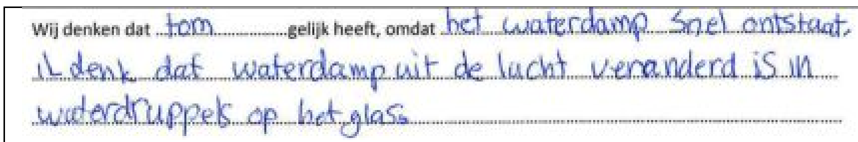

Wij denken dat tom gelijk heeft, omdat het waterdamp Snel ontstaat, ik denk dat waterdamp uit de lucht veranderd is in waterdruppels op het glas

Figure 22 Group claim

We think that Tom is right, because the water vapor appears quickly. I think that water vapor from the air changed in water drops on the glass

Despite the writer being in control of the arguments written in the worksheets, from this script we can see that they do listen to each other and they sometimes use observations. But is the argument being resolved by reasoning with evidence and concepts? Not really.

The worksheets were very helpful in structuring the discussion and designing experiments. It has to be taken into account though, that the amount of writing expected of the children can also be inhibiting. It takes up time which then cannot be spent on discussion and it could kill discussion. One possible way to go around this problem is to introduce the worksheet after the discussion, asking the children to summarize their discussion and write down their arguments.

In the Friday experimental lessons, the children were asked to present their findings by the Presenter of the group. The teacher and the other children were allowed to ask questions en give feedback. The children learn in this method about different ways to look the concept and different ways of collecting data. However, to be able to give proper feedback and to ask questions to get a better idea of what the children learned about the concept and about experimenting, there should be enough time for each group. In a normal school day, time is limited. In our lessons, there were 7 groups of children, so also 7 presentations. To improve the level of presenting the findings and the feedback given by the teacher and other children, is would probably be better to just have two groups present their findings and in the next lesson another two groups. Another option is to think about different ways of presenting, for instance poster presentations.

LL1 We think that Tom is right because LL3, LL4 Yes LL3 I think that Joris is right LL1 No, because the glass becomes wet, because the cold in the… changes in the water that glass, that is not true because water vapor.. LL3 That's right, with cold LL2 Strange! LL3 Cold! LL1, LL2 Water vapor LL3 Cold is from, cold is from that stuff that comes up when it is very cold LL5 Look, guys, look! LL5 That is also water vapor LL3 Where? LL5 Look, look under! What the glass does, that is water vapor	LL4 Yes, that is just water LL5 It drips down LL# Yes, just look, look LL1 Tom is right because LL3 Because look, it is cold and then it goes outside, and then it becomes up that cold, then it goes up, and sinks down again LL1 Come on, no! For the umpteenth time! LL3 Shut up! LL1 Timo is not right LL4 But Timo is right LL4 It is water vapor LL3 But I give my opinion, just let me say it LL2 We think that… LL1 That Tom is right because

Figure 23 Discussion on condensation

Conclusions

Can cartoons function as low threshold tools to get children to design their own experiments?
Yes they can, in our Dutch heterogeneous grade 5 class with children who had little or no experience in experimenting and hands-on learning, the children spontaneously and creatively thought of experiments. Of course some cartoons inspire more experimental ideas than others. The Shadows cartoon inspired least while the skateboard cartoon inspired most. Our experience in different schools and with different grade levels ranging from grade 4 – 6 also supports this conclusion.

Does this process lead to reasoning with concepts and evidence? Concept cartoons are indeed an effective stimulus to trigger argumentation and scientific investigations. The way the cartoons are presented is easy accessible and little preparation is needed to get the children started. However, the comparison between claims, actual experiments, and conclusions showed that these children -who lacked prior experience with IBSE- still have a lot to learn about connecting between claims, experimental set-up and results, and conclusions. That is to be expected.

Which problems do students have in reasoning with evidence, or, specifically with designing and executing experiments and drawing conclusions? Which guide rules or suggestions can be given to the teacher to obtain maximum results with respect to reasoning with evidence and concepts?
We found that intervention from the teacher will help to get more out of concept cartoons and having observed the activities, we can now give more focused teaching suggestions for each cartoon.
When the children have more experience using materials and designing experiments, the teacher can help the children to interpret their data, to use variables, to use control experiments, etc. to improve the level of experimenting. In that way they are scaffolded to use evidence when making a claim and using arguments to support their claim. Most children do not show these skills by themselves without structured feedback and intervention from the teacher. We indeed need a long term teaching process to teach students 1) to write down experiments properly, 2) to distinguish between observation and interpretation, 3) to back up claims with evidence.
The role of the teacher is therefore an important one as this study has shown. Chin and Teou (2009) also stated that children need scaffolds for structuring the discussions, ground rules improve engagement

and that guiding whole-class discussions, like the presentations at the end of every second lesson, needs to be done skillfully to elicit children' understanding.

The teacher can bring the use of concept cartoons to a higher level by carefully planning when and how to introduce which particular concept cartoon and scaffold the discussion and the process of designing experiments and using the evidence for backing up claims.

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