Learning Journey: A wisp of air

Moving on or with air. Can you move a ball, a plastic bottle or a CD with air?

Age: 7-8
Learning activities: Questioning, making connections, explaining evidence, communicating explanations
Synergies:
Dialogue and collaboration, reflection and reasoning
Creative Dispositions
Motivation, ability to come up with something new, ability to work together, thinking skills.

Background

School setting: This is a school in an urban environment with a mixed audience, with a social and ethnical mix. There are a number of language poor children. Therefore, in every lesson attention is given to new vocabulary and verbal communication, ... The number of children has increased significantly the last few years. Because of this there is a shortage of space in the school. So, there are no specific areas designated for STEM activities or to store STEM-materials.

Setting the Scene

Context: This is a 50 minutes lesson. I'm not the main teacher in this classroom I work with this class only once a week. This is the third lesson in a series of STEM-lessons. The first lesson was about building strong towers with wooden blocks. The second lesson was about building sturdy bridges with A4 paper. The children are open to challenges, they often ask me when there will be another STEM lesson where they can design and investigate. The children are really looking forward to these lessons. They know they will be facing challenges. Unlike the previous lessons, a lot of material is offered to the children so that they can experiment a lot. The previous lessons focused primarily on finding a technical solution. During this lesson we will also focus on finding and articulating a scientific explanation.

Rationale

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- I wanted every child to be involved in the process. I wanted them to really cooperate with each other and discuss problems with each other by asking questions. It is also important that every child has a feeling of success. In this way they will remain motivated for school.
- The children like these kinds of challenges and are very motivated by them. This creates learning opportunities. They are motivated to seek solutions and explanations. They also learn to communicate with each other (ask questions, find explanations and articulate structured solutions, ...). They will present their results to each other with a lapbook (draw three take-home-messages creatively).
- There are a number of language poor children in the class. Due to their intrinsic motivation during the problem solving process, they are encouraged to express their thoughts and ideas to the other group members and to the class.
- Children are encouraged to work together because they have to present their results to the class together. Through this collaborative process on a common challenge, the children will find more and better ideas.
- By articulating their scientific ideas, the children will gain a better understanding of scientific phenomena and the learning effect will be stronger than if these scientific ideas are supplied by e.g. movies, books, teacher, ...

Focus

- Increase participation and motivation to find creative solutions, among others by working with a lot of material.
- Ensuring successful experiences for every child, by providing information sheets and tablets with instructional videos.
- Expand the vocabulary of the pupils by offering post-its where new words can be recorded. This will be added to a learning wall.
- Encourage children's questions and reflection about what they see. Ask questions to each other by using the question words noted on the blackboard.
- Working collaborative in heterogeneous groups, which children choose according to their interest.
- The children search for an explanation of the observed phenomena and formulate these as clearly as possible to their peers (rather than providing scientific explanations to the children myself). The children discuss their scientific explanations.

Implications for planning and teaching

- Increase participation:
    - I provided a large amount of material. In this way children are encouraged to find more solutions, and ask more questions.
    - We start from a challenge, I know this really works in this class.
- Success story for every child

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- By using step-by-step guides and instruction videos: after a while the children receive an info sheet with information. In this way everyone can find a solution and it will be a successful experience for every child.

- Enrich their language (dialogue)
  - New vocabulary on post-its is attached to the blackboard to improve their vocabulary and dialogue
- Ask each other questions
  - Note 'question' words on the black board
  - Reflect about what they see and ask questions about it (reflection)
  - Stimulate children to look for logical explanations and reasons (reasoning)
- Work collaboratively in heterogenous groups (collaboration)
  - The children work in groups. They choose the challenge that they want to work on and in this way the groups are formed. The group size varies between 2 and 4 children. The group size is limited. In this way, everyone has ownership.
  - I let them choose the group, a maximum of 4 members is allowed
- My role:
  - I will coach the children during their search. They get time to find a solution without additional information. I will not give solutions. I let the children explore and make mistakes. I let them try out their design even when I know it will not work.
  - Over time, the children can, if they wish, receive a fact sheet with additional information and a roadmap to reach a solution.

Outline of learning activities and resources

We start this lesson from a challenge: "I would like you to make something that moves on air." The children first try out a few solutions without additional background information. They get a lot of material: balloons, rope, clothespins, tape, CD's, caps of sports water bottles, straws, construction paper, scissors, ... After a while the children get information sheets with additional information in order to reach a solution. At the end of the lesson the children present their solution to each other and give explanations.

Developing the Learning Journey

Starting Point

In this phase I want to **motivate** them for this challenge and I want them to become interested in the topic. I want to give them the opportunity to **reason** …
As motivating starting point the children explore their prior knowledge of air: *Who can explain what air is? What can we do with air?*

- They inflate a balloon and it snaps. *Who can explain this?*
- They let go of an inflated balloon. *What happens now? The air escapes the balloon and the balloon moves in different directions. What makes it move?*

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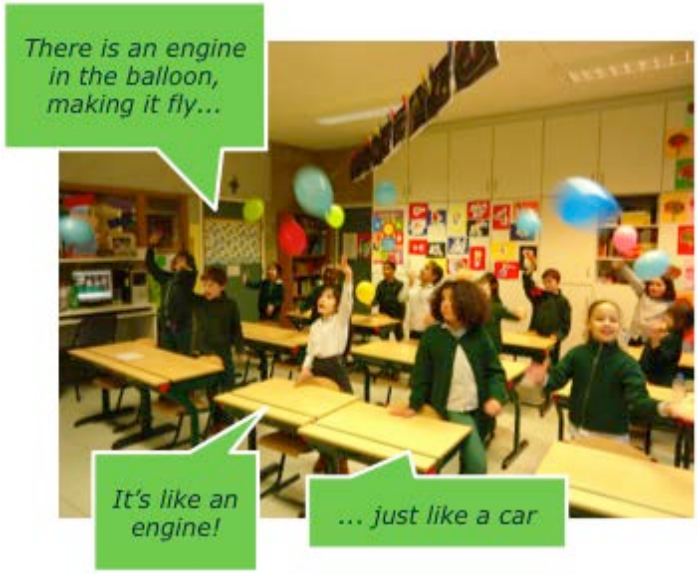
- The children express their ideas: *It is like an engine. There is one in the balloon. Air flies out, and so the balloon can fly. It's like a car going forward.*
  Teacher: *Air comes out of a car? Is that true? Where do you feel the air?*
  Child: *Air leaves at the back of the car and that makes it move* (misconception).



Implications:
I notice this really motivates the children. I want to address some misconceptions. The challenge will give the children the opportunity to investigate their ideas. Children will be able to connect what happened during this phase with the challenge.

Activity 1

After this starting point the teachers moves on to the main assignment of the lesson: *I would like you to make something that moves on air*. She has three different assignments between which the children can choose.

- The first possibility is to construct a 'balloon aircraft': '*Construct a device that moves from the front end to the back end of the classroom in a straight line only using air*.' The children discuss in their group how to handle this. Some ideas emerged from the children (every idea is later on tested and discussed why it does or does not work):
  - *Inflating a balloon and letting it go*. This led to a discussion among the pupils: *The balloon must be properly inflated. But the balloon does not fly in the 'right' direction. The balloon needs a steering wheel, you should be able to steer the balloon.*
  - *We can attach the balloon to a car. When air leaves the balloon, the car will move.*
  - *We can manually push the balloon in the right direction*. This does not comply with the requirements: the balloon should move by itself using air only.

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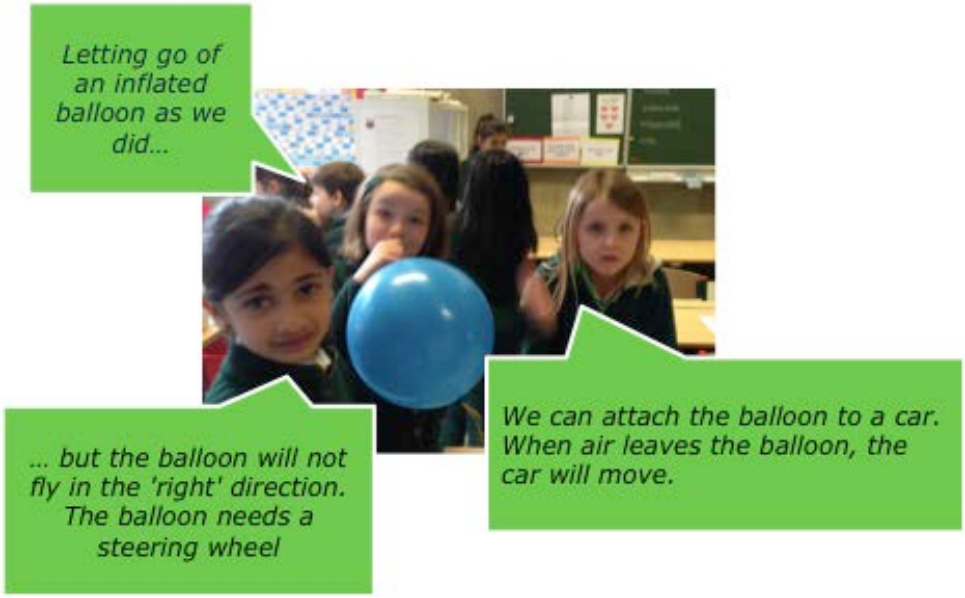

- The second possibility: The teacher shows how she can make a little polystyrene bead fly with a hairdryer. She discusses this phenomenon with the children. They come to the conclusion that they could make a 'wonder blower', something which makes the ball float in the air (eventually nobody chose this assignment).
- The third possibility: the teacher shows a film about a hovercraft and a train moving on air. This leads to the assignment: construct something that moves on a cushion of air.

In summary, the children investigate in groups one of these three possibilities. The suggestion of the car is added as a fourth option to investigate. This was initially not planned by the teacher but builds further on the ideas of the children. The children are free to choose. At the end, they should be able to explain what they have done during the process and why it works or doesn't work.

Activity 2: Let's get to work

The activity starts with a free exploration of available materials (placed at one side of the classroom): children discuss in their group which materials they need for the assignment. They explore the presented materials and agree on which materials they want to use and how they will use them.

- Assignment 'balloon aircraft ': Some children examine how they can attach wings to the balloon. Other pupils investigate whether connecting several balloons to each other ensures that the balloon can fly a larger distance
- Assignment 'something that moves on a cushion of air ' A child investigates how they can fix a CD to a balloon.
- Assignment: 'the balloon car': luckily the teacher has a spare car in the cupboard of the class which the children can use to explore their ideas.
- During this phase the children explore and tinker. Most groups do not find a working solution during this phase.

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Implications:
It is hard for the children to find a solution. To keep them **motivated**, the children will get more concrete information on how to find a working solution

Activity 3: sharing step-by-step guides

- The teacher shares step-by-step guides with information. The children explore these and collect the necessary material or make changes to their original design. The teacher asks questions: *Why doesn't it work? Look carefully to what is happening? Think about what you might adjust.' What would be the effect if the balloon is inflated more?, ...*
- I notice that some children rush into the task and are not analysing the step by step guide enough. Some children use trial and error. Not all of them find it easy to keep on trying. I ask questions to encourage them to reason and keep on searching for a solution. When they present their results to each other, they will have the possibility to reason with their pears.

Implications:
To make sure the children **reason** about their solutions, they will present their solutions to each other. They will get the opportunity to optimize their design based on their **explanations.**

Activity 4: sharing results

- The children show the class the results of their assignment and test their design. They discuss the 'making of' and confront their scientific ideas about how air makes their design move with the class group.
- The hovercraft:

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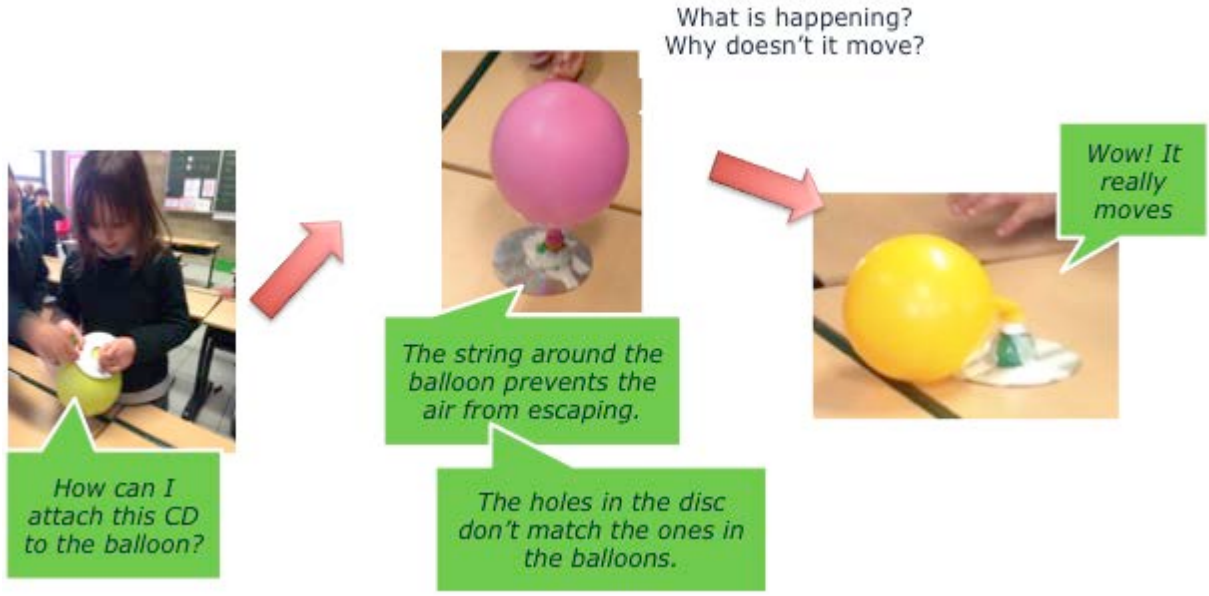
- Group 1: *First, the bottle cap was attached to the CD with sticky tape. The inflated balloon is fixed to the cap with tape. A clothes peg ensures that the air cannot escape from the balloon. When the peg is removed, the air will pass through the hole of the CD and escapes from the downside of the CD. It lifts the CD and in this way it starts moving.*
- Group 2: At first the try-out fails. The teacher encourages the children to explain what may be the cause. Child: *The air cannot pass because there is a piece of string around the balloon to attach the balloon to the CD*. The teacher asks: *How can we solve that?*
- Group 3 - The task fails, the children look for explanations: '*The balloon is not attached in the middle of the disc. In this way the air cannot escape from the balloon*.'



- The balloon aircraft:
  - One group tried this. The first attempt fails. The balloon goes flat but does not move.
    Teacher: *What did you expect to happen? Why did it fail?*
    Child: *The balloon was fastened too hard.*
    Child 2: *Also the straw was obliquely attached to the balloon.*
    Child 3: *The wings are too heavy and there was too little air in the balloon.*
    Teacher: *OK, make the adjustments which you think are needed.*
    The children blow up the balloon more strongly and cut of a piece of the wings and test again. This version works better. The balloon moves forward, however it does not reach the end of the rope. The children wonder whether the model would work better if they cut the wings even more. They recognize that the air should leave the balloon fast enough to be able to move the balloon forward. After cutting off the wings, the aircraft flies over the entire length of the rope. The

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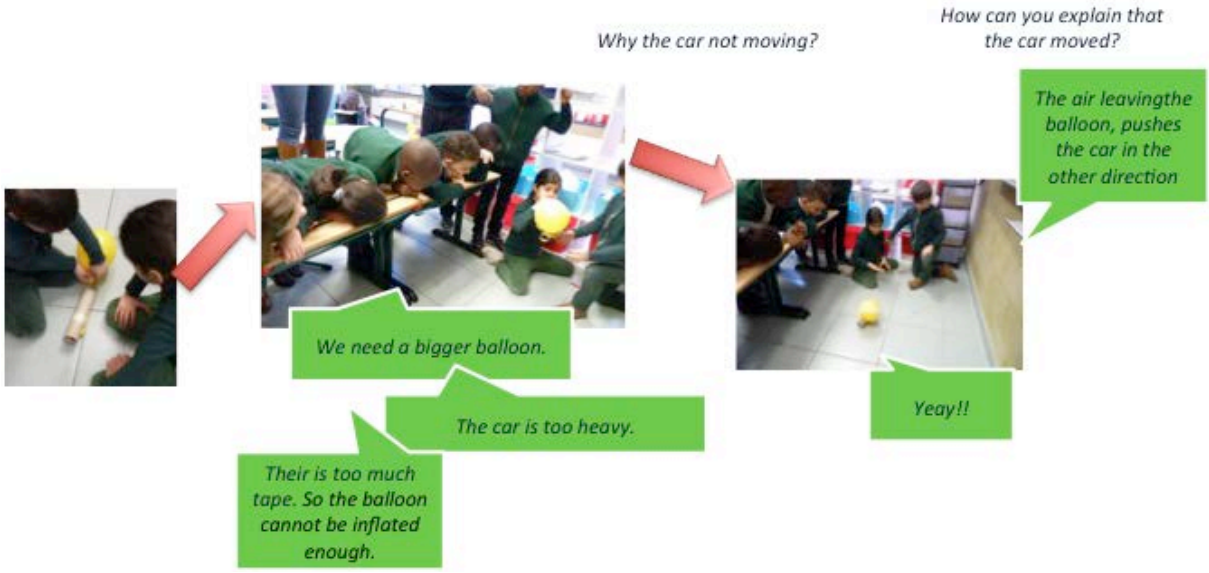
children are proud that they adjusted their design to their growing insight.

- Balloon Car:
  Group 1: The first attempt failed.
  Teacher: *What do you think, why doesn't it work?*
  Child: *There is too much tape, so the balloon cannot be inflated enough*
  The children adapt their design and test it again. Now the car moves forward.
  Teacher: *Can you explain why the car is moving forward?*
  Child: *The air leaves the balloon at the rear end and makes the car move in the other direction. The air pushes the car forward.*
  Group 2: The first attempt fails, the children reflect: *Maybe the car is too heavy or the wings are too heavy? Maybe more air is needed to propel the vehicle forward. With a larger balloon it may perhaps succeed?*



Implications

Children find real scientific explanations. However, the **connections** the children made through **reasoning** and **collaboration** need to be secured (e.g. in a lapbook) or by doing more experiments.

Reflections

Children's progress

- All the children were really **motivated** to solve the problem (motivation). They were **looking for solutions** themselves as soon as they started exploring the different materials. Some groups really **cooperated** and worked together to find a solution (dialogue and collaboration, ability to work together). The children realize that it is possible for them to come up with explanations for natural phenomena.

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- The children investigated various solutions as soon as they were allowed to explore the materials. This indicates their motivation and desire to work together. They found **unexpected solutions** for the problem (ability to come up with something new) and found **explanations** for the phenomena themselves (thinking skills).
- The children used their **previous knowledge** of the materials to come up with hypotheses (making connections, reflection and reasoning). Testing their first prototype gave them ideas on how to improve it to reach the goals and meet the predefined criteria.
- The children were encouraged to communicate about their designing process, the possible scientific explanations and the problems they encountered. However, the children are **not asking enough questions**, I need to push them to do so. The questions came mainly from me. During the exchange of solutions however children started to reason more spontaneously (questioning).
- The children were **stimulated to explain the activity and communicate problems** they encountered along the way (explaining evidence, communicating explanations).
- I noticed that children are able to come up with correct scientific explanations and that they can share insights with each other (e.g. balloon moving forward, because air escapes at the rear end)
- They realized that using the correct terms helped them to articulate their insights.

Unanticipated outcomes

- The children came up with new and creative solutions, other than those I had anticipated for. E.g. They proposed a solution with a toy car. Fortunately there was one present in the classroom, so that children could develop their own ideas.
- When making groups, they often chose for their friends and not for the subject. This did not always result in good solutions. During the evaluation they could express why their design did not work: they lost too much time talking about details or didn't get along...
- Some children were surprisingly good in coming up with scientific explanations and some showed a lot of courage to try out new things.

Children's reflections on their learning

- The children experienced that they can learn a lot from one another, both within their group and from other groups
- Children know each other well: who has a good insight in certain processes, who is a good leader, who is less good at keeping up with the rest...
- While they learn how to express their learning process, they evolve in their initiative to take action. Timid children get confirmation of their ideas when a test succeeds, and will dare to do more the next time.
- As they learn to vocalize their insights and learning, they also evolve in taking action.

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Teacher role

- I tried as much as possible to follow the ideas of the children, even though they did not seem feasible to me. I think it's important that they have ownership, and that they are allowed to make mistakes and learn from these mistakes.
- I have tried to improve their language and vocabulary. I planned to write question words on the black board, but due to the tight time schedule this was unfortunately not possible during this lesson.
- I challenged, together with the class teacher, the groups to **make predictions** of their experiments. That way we hoped to minimise the amount of trial and error: making them think first about what they were going to test. Also, I tried helping them to formulate their sentences in this way: *I thought it would... but now I see that... because...* (reflection and reasoning). I hoped that they would not just try anything that popped up in their mind. I really wanted them to think and predict to what a certain action would lead.

Classroom environment

- During the STEM classes the children really have the feeling that they can find the solution themselves. This encourages them to focus on the assignment. They have ownership and do not feel restricted to present their ideas. All ideas are welcomed and the children get the opportunity to work on their ideas. In this way, their creativity really gets a chance. After all, creativity can only thrive in a group when all ideas are welcomed. Otherwise, children may become self-critical about their ideas and wish no longer to express them.
- The children understand that it not the quantity and variety of materials which is important, but the way in which materials are used. During the third STEM lesson also useless equipment was provided to the children. The children quickly realised which materials were better to work with and which leaded to a successful design. They became pickier in this way...
- A 50 minutes lesson was really short. More time could have improved the discussions of the children.

Next steps for learning and teaching based on evidence of learning

- The **connections** the children made through **reasoning** and **collaboration** need to be secured. They need to see other applications, so they will be able to transfer their insights. Therefore, we will explore these further during new experiments. Based on the photographs and videos that were made during the lesson, I would like to visualize and analyse their learning process together with them. I want to guide them in making a learning wall (their questions, starting points and new concepts which were discussed during class, the formulation of 'scientific' research) and securing the learning content in a lapbook.
- I would like to encourage them to look for natural phenomena in their daily lives. And then encourage them to seek an explanation for these phenomena

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(e.g. What makes a pinecone open or close? What makes...). I would love it, if they could find and describe cause-effect relationships themselves.

Reflection questions for the reader

- How do you encourage reflection and reasoning during science lessons?
- How do you encourage your children to expand their language and vocabulary during STEM lessons?
- When were you surprised by the creative ideas of the children in your classroom? Were you able to create opportunities in the classroom to work on these ideas? How did you do this?

Practical information - resources, tasks, lesson plans?

- het ballonvliegtuig: https://www.e-nemo.nl/media/filer_public/9c/cf/9ccf6821-5f99-42c0-8c8e-583fc523ac3e/1straalmotor.pdf
- de hovercraft: https://www.e-nemo.nl/media/filer_public/ed/5d/ed5d04fa-1963-4157-a866-e706860cb0f8/4zweven_op_lucht.pdf http://auto-en-vervoer.infonu.nl/diversen/78036-alle-informatie-over-hovercrafts.html http://www.sciencespace.nl/technologie/artikelen/4040/de-hovercraft
- 'Hallo wereld! We gaan de lucht in.' Uitgaven van het Expertisecentrum Wetenschap & Techniek Noor-Holland/Flevoland, september 2012
- De wonderblazer: http://www.kidzlab.nl/index2c83a.html?option=com_content&task=view&id=96&Itemid=57&pop=1&page=5

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