Sugar transport

Focus on problem solving

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

Practicalities

Preparation: < 0.5 h

Duration: 2h45' - 3,5 hours of 50'

Material needs:

- cardboard
- wood
- lasercutter
- rope
- 3D-printer
- Tape

Group size range: maximum 24
Ideal sub-group size: 4

Workshop made for: 12-16/+16
Easily transferable to workshops for ages between: -12

Environment FabLab necessary: no, but preferable. Pasta bridge is possible if you have glue guns ☺ (see resources @end of document)

Educational area:
* Computer science
* Engineering
* Mathematics
* Science
* Technology

Precognition

The participants do not need to know anything about bridges, catapults, slides or conveyor belts because they can perform research on the chosen path

(see box ‘content links’ below)

Preparation

Create groups of 4 (ideally).

Each group needs to transport 2 kg of sugar cubes from one side of the room to the other side: ideally everybody crosses the same distance so there are tables on one side and on the other.

In a fablab just make sure they all have to cross a fixed distance, for example 3 meters.

Workshop Guidelines

Phase 1: Orientation and instruction phase

Material needs:
Essential: Essential: computers, laptops, tablets or smart phones to look up designs, see real live applications to transport large bulk goods, and investigate what will work for them.
Optional: /

Goals:
Skill Goals (**Blue**)
(S1) working together
(S2) leadership: democratic leadership (who takes up what role)
(S3) communication: listening, explaining, asking questions, agreeing on certain aspects, organizing (different roles)
(S4) problem solving: solve the problem of transporting the goods
(S5) social skills: reading the group, reading the others, becoming part of a whole, adding personal value to the team
(S6) Self-regulation
(S7) Critical thinking
(S8) Creative thinking

Content Goals (**Green**)
(C1) *Spatial insight*
(C2) triangles in supporting structures
(C3) Research based learning
(C4) distributing weights through spreading of contact on surface

Background story:

This workshop is based on problem solving:

The student need to get 2kg of sugar (cubes in a package) from one place to another by building a construction that gets the sugar across. Students cannot carry or push the load along. They can put the package in or on the construction on one side, and they can get it off the/a construction on the other side, but they CANNOT throw or catch the sugar cubes themselves. Working together is obliged (team work). Building by using more ecofriendly material is promoted with the entrepreneurial badge. If you can build with pasta or cardboard, this is more ecofriendly than using wood of plastics.

Goals	Activities	Duration
S1-S8 C1-C4	Give the problem which students have to solve: - Getting the sugar across from one side to another without human aid (only loading on and loading off is permitted). Give them the amount of time they have: usually 4 hours, but you can lengthen or shorten this, but you need to communicate in order to let them plan. Show them the infrastructure they can use: guide them through the fablab/makerspace or show them what you have in your classroom or project room.	15'-30'

Phase 2: Design phase

Material needs:
Essential: Essential: computers, laptops, tablets or smart phones to look up designs, see real live applications to transport large bulk goods, and investigate what will work for them.
Optional: /

Goals:
Skill Goals (**Blue**)
(S1) working together
(S2) leadership: democratic leadership (who takes up what role)
(S3) communication: listening, explaining, asking questions, agreeing on certain aspects, organizing (different roles)
(S4) problem solving: solve the problem of transporting the goods
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(S6) Self-regulation
(S7) Critical thinking
(S8) Creative thinking

Content Goals (**Green**)
(C1) *Spatial insight*
(C2) triangles in supporting structures
(C3) Research based learning
(C4) distributing weights through spreading of contact on surface

Goals	Activities	Duration
S1-S8 C1-C4	Designing will take place in group: First they will brainstorm on the possibilities, next they will look up and then they will plan on the material they need to build their construction. THIS will all depend on the material available… AND what they decide to build.	15'-30' 15'-30' 15'
	Here are some examples of things the pupils can build. Don't show them the examples, let them thing about a solution themselves! A **bridge** will be the most commonly chosen path: there are a lot of instructional videos on bridges, but this time the bridge will have to be higher on one side, so the sugar slides from top to bottom. A **cardboard slide** will probably also be popular. Especially when you have large pieces of cardboard available: chose this when you don't have lots of time! A **death ride** is possible if you have fixed points in the ceiling that can be used to attach ropes to.	

	A **catapult or trebuchet** is also a possibility that will be thought of, but they will need a net then, because they cannot catch the sugar themselves. Plans are easily found online, but they will need to be able to use a lasercutter then. (links in resources) A **conveyor belt** is really advanced, but a valid choice. Plans are also available online but will need a 3D-printer and some small metal parts (links in resources).	

Phase 3: Making phase

Material needs:
Essential: computers, laptops, tablets or smart phones to look up designs, see real live applications to transport large bulk goods, and investigate what will work for them.
Optional:/

Goals:
Skill Goals (Blue)
(S1) working together
(S2) leadership: democratic leadership (who takes up what role)
(S3) communication: listening, explaining, asking questions, agreeing on certain aspects, organizing (different roles)
(S4) problem solving: solve the problem of transporting the goods
(S5) social skills: reading the group, reading the others, becoming part of a whole, adding personal value to the team
(S6) Self-regulation
(S7) Critical thinking
(S8) Creative thinking

Content Goals (Green)
(C1) *Spatial insight*
(C2) triangles in supporting structures
(C3) Research based learning
(C4) distributing weights through spreading of contact on surface

Goals	Activities	Duration
S1-S8 C1-C4	Making will need different tools depending on what they chose to make: Bridges can be made without high tech tools, but in a fablab a lasercutter and cutter knives will be used most of the time. A slide needs cardboard, tape, glue and scissors or cutter knives. A catapult or trebuchet will need a 3D-printer or lasercutter (best option because it's faster (+ time)). A conveyor belt will needs a 3D-printer, some small electronics and small assembly parts. A death ride will need rope.	1h30'-2h

Phase 4: Operational Phase

Material needs:
Essential: same as above

Goals:
Skill Goals (Blue)
(S1) working together
(S2) leadership: democratic leadership (who takes up what role)
(S3) communication: listening, explaining, asking questions, agreeing on certain aspects, organizing (different roles)
(S4) problem solving: solve the problem of transporting the goods
(S5) social skills: reading the group, reading the others, becoming part of a whole, adding personal value to the team
(S6) Self-regulation
(S7) Critical thinking
(S8) Creative thinking

Content Goals (Green)
(C1) *Spatial insight*
(C2) triangles in supporting structures
(C3) Research based learning
(C4) distributing weights through spreading of contact on surface

Goals	Activities	Duration
	Operational phases will take place in production and testing (feedback on designs): Does it work? What needs to be altered? How can we improve? What doesn't work?	15'-30'

Phase 5: Evaluation phase

Material needs:
Essential: same as above

Goals:
Skill Goals (Blue)
(S1) working together
(S2) leadership: democratic leadership (who takes up what role)
(S3) communication: listening, explaining, asking questions, agreeing on certain aspects, organizing (different roles)
(S4) problem solving: solve the problem of transporting the goods
(S5) social skills: reading the group, reading the others, becoming part of a whole, adding personal value to the team
(S6) Self-regulation
(S7) Critical thinking
(S8) Creative thinking

Content Goals (Green)
(C1) *Spatial insight*
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Goals	Activities	Duration
	Evaluation will take place every testing phase. If it doesn't work, it is adjusted. If it works, it's used.	
	Teacher and others are called when they want to show and tell + let their work be tested by others.	15'

Pedagogical tips

Strive to make teams of 4 or near 4 participants.

Use a large room with an open path in between tables to put al the constructions. Avoid working on the ground – make workstations (tables for group work).

Use a research area (computers)

How to transfer to non-Fablab environment

Use card board or pasta.

If you want to use trebuchets, you can let them be lasercut in advance, but consider that this level 4 workshop will
become a level 1 workshop, because it's just a building kit then (following a recipe – manual).

Evaluation of achievements

Every test-moment is an evaluation, but the final feedback round is the moment to gather the entire group (all the teams) and ask what they learned from each other during the research, the making and the testing + WHAT they altered and WHY.

Content links

Tips/background on material:
You can use 4 packages of half a kilogram of sugar cubes (easiest): the structure only has to bear 0.5 kg at a time. These packages are easy to get as well.
Packages of 0.75 kg, 1 kg or 2 kg are harder because the weakest part of the structure has to be able to bear that weight.

Resources

Teachers doing this workshop in a fablab/makerspace:

https://www.facebook.com/fablabplus/posts/1747615942040800

Teachers doing this workshop in a non-fablab environment:

https://www.facebook.com/fablabplus/posts/1747621788706882

Triangles used in building:

https://www.youtube.com/watch?v=mBHJtWbsiaA

https://sciencing.com/triangles-used-in-architecture-12084289.html

https://www.youtube.com/watch?v=AoS0UvVfxRQ

pasta bridge with skies:

https://www.youtube.com/watch?v=xN0poIrm0q8

lasercut trebuchet:

https://www.youtube.com/watch?v=G6ftSuJF9zQ

https://www.thingiverse.com/thing:925096

Conveyor belt:

https://www.youtube.com/watch?v=zpzMnF_jOWc&feature=youtu.be

https://www.thingiverse.com/thing:3031479

Blogpost about this workshop:

Blogpost: Sugar Transport – an Artifex workshop @FabLab+ (Antwerp – Belgium): designing creating – higher level learning

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A Wednesday afternoon in a fablab or makerspace near you…

4 groups of teachers (primary and secondary education) of the Municipal Education of the city of Antwerp were given 2 kg of sugar and ask to solve a problem:

> 'Get these 2 bags of sugar from one side of the lab to the other side of the lab. Everything that's available in the lab is at your disposal. 2 restrictions apply: you can't carry the sugar yourself and you can't throw or catch it. In other words: create a contraption to transport the sugar for you!'

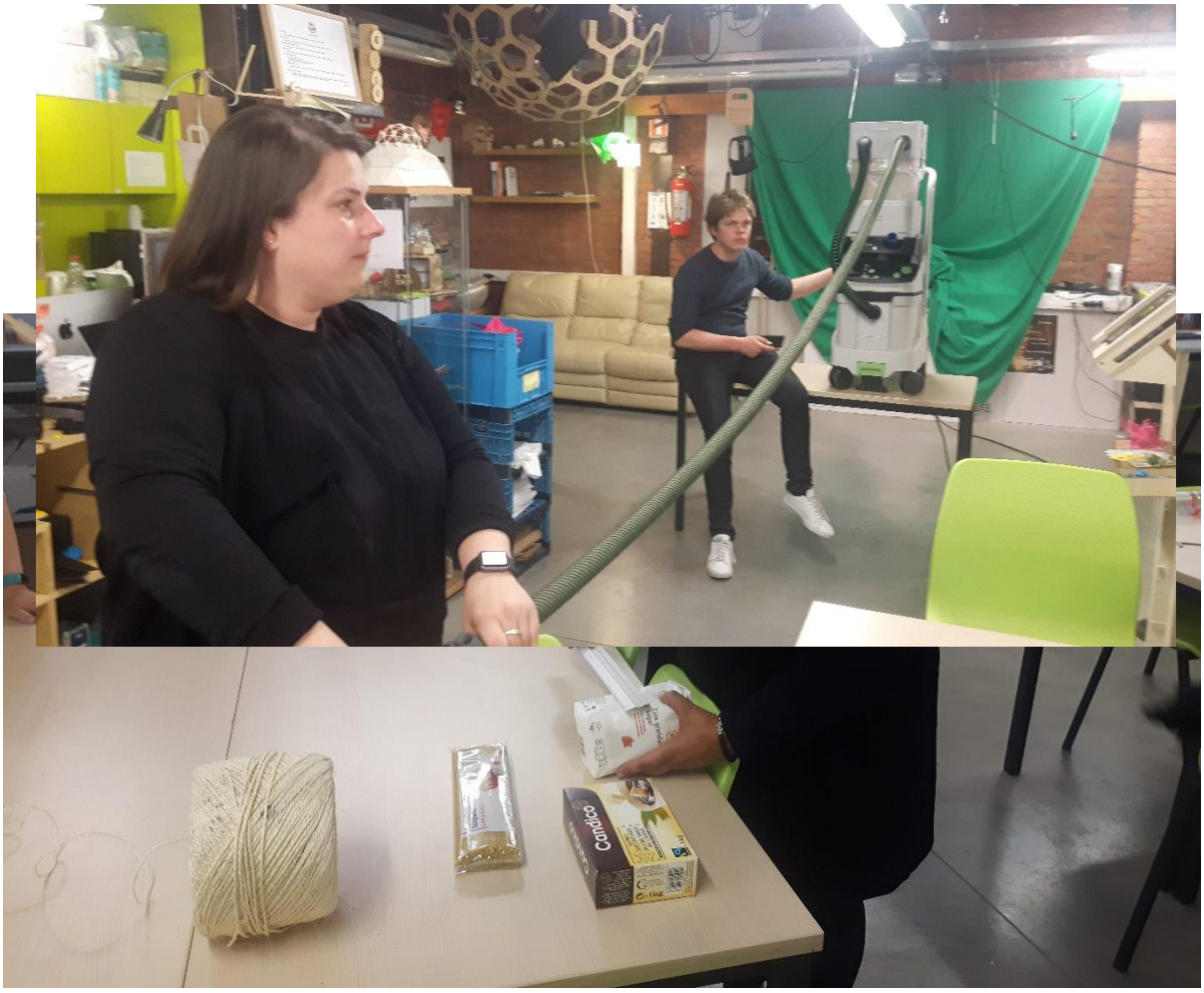
The 4 groups eagerly started, but applied different strategies:

- Team 1 started exploring the ideas of tubes and suction. Therefor they were going to transport the loose sugar. They started with what they knew and were going to tackle the problems when they arose. They did arise, but I'll come back to that...
- Team 2 started exploring the idea of a death ride (gravity). They started with measuring the bags of sugar and started drawing and designing a possible solution. They also wanted to use robotics, so they decided to bring the second bag of sugar across with the Nao.
- Team 3 decided on the idea of skilift to transport the sugar packs. It looked like the death ride, but uses traction instead of gravity.
- Team 4 wanted to use robotics. They went for the Lego Mindstorms (EV3). This meant they had to design a cart and program the robots.

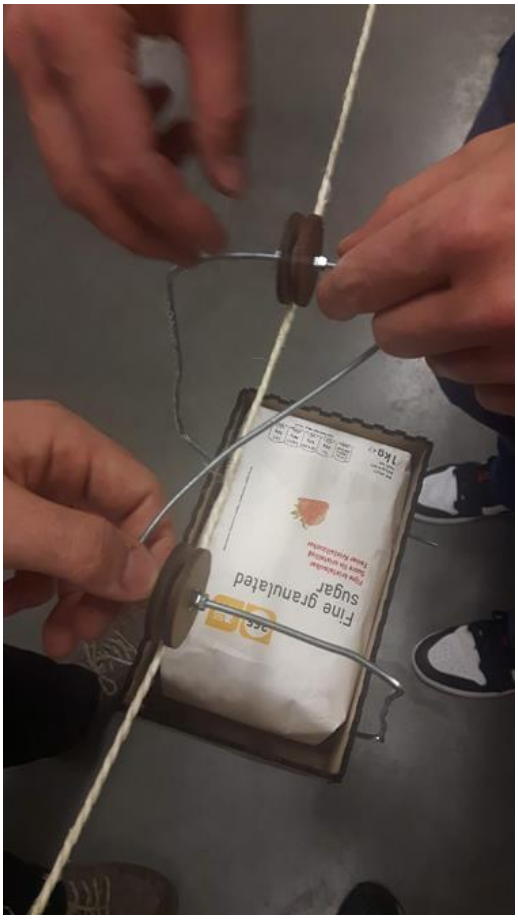
The story continues: Who won, who solved the problem and how do you grade this?

Team 1 made a construction using tubes and the suction of a vacuümcleaner that was in the fablab. It worked and surely must have given them a clear and flawless victory, but 20g of sugar seemed to remain in the tubes. As a teacher you have a choice here: Do you give them the victory (after 25') or do you ask them to solve this issue? The latter of course! Everyone should be able to fail and learn through this. When evaluating, they and you should ask how to improve what they constructed. Team 1 put their minds together and created a blaster, to clear out the remaining sugar from the tubes. They used build-

up air pressure and marbles to check if they got everything out. For some time it seemed like 1 marble was missing. But the culprit was hiding in the sugar receptor. All sugar accounted for and no more lost marbles: team 1 delivered!



Team 2's death slide was also coming along. Two baskets were lasercut to each fit one bag of sugar and the strings of the death slide were connected to the ceiling. Everything seemed to be on schedule, but the sugar did not reach the other side. Time after time it settled in the middle. The construction was reviewed and adjusted for a couple of times, until it worked. As you will see in the video, a member of the other team felt rather safe because it didn't succeed the first 3 times, but the joke was on him! (He's fine!)



The first bag of sugar was through, now for the second bag! The lasercut basket was tied to the Nao and the robot was programmed to walk across. Team 2 needed two tries, because the first one bumped into a construction that was in the way, but team 2 succeeded and delivered!

Team 3 needed the most time to prepare and construct their installation, but their contraption worked from the first try. They brought over the first bag of sugar and I wasn't even ready to record it. Fortunately I was able to record the second bag of sugar which they transported (even faster) and they also succeeded in solving the problem!

Team 4 had only 2 participants, but they also finished ahead of time. One of the teachers knew how to program an EV3 and selected a path for the robot. Because of the many obstacles in the fablab, they layed out 2 wooden beams to keep the robotic car in its given trajectory and they fabricated 2 carts to hang onto the robotic engine. In the beginning it all went like a charm, but just before the finish line, the robot started to struggle. Engine failure? Was the load too heavy? No, the batteries were running low. But, he made it!

Everybody succeeded, everybody passed. But how do you grade this? You gave them a problem and they solved it so they haven't failed. But as you can tell, they all used different applications. In a fablab, we love these open endings where anything goes, but in a classroom (or if you and your class are visiting a fablab or makerspace) you can give more directions and boundaries. Just make sure you see what they are preparing, looking up, adjusting. Use formative evaluation or check which competences the students have and developed: Do they communicate? Which are the leaders? Which are the critical friends? Can they evaluate one another? A checklist can help, but also if you make them report what they did. This could be written down or be vlogged with a device, as long as there's something to evaluate or to make the process reproduceable for someone else!