

# A GENDER-BALANCED APPROACH



**PHABLABS 4.0**

**Hints&Tips for Organisers of  
Fab Labs and STE(A)M-activities**

**INSPIRING THE NEXT GENERATION**

**Prof. Averil Macdonald OBE commissioned by the PHABLABS 4.0 consortium**

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photo by Fab Lab Erpe-Mere





# MORE GIRLS IN STEM

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

More girls and young women deserve the chance to have successful and satisfying careers in science, technology, engineering, manufacturing and construction (STEM)! And the STEM sectors can only benefit from the talents of these young women. We, in the PHABLABS 4.0 consortium, are eager to share this information with you so that you can play your part in this revolution!

## STEM, say what...?

Science. Technology.  
Engineering. Mathematics  
The four components of STEM are important individually. But the strength of STEM is solving problems and improving lives through cooperation at the boundaries where science, technology, engineering and mathematics interlink and where, of course, they link with the social sciences and professional fields.

## STEM in action

To make STEM courses and professions more attractive to girls and young woman, there needs to be global partnerships across the STEM sectors. The PHABLABS 4.0 consortium is determined to put in the extra effort to put STEM, and in particular the combination with photonics (the science of light and light technology) in the spotlight. Together, we can stimulate interest and passion for STEM, increasing STEM literacy and expertise and make STEM courses and professions more attractive.

## Gender Action Team

The PHABLABS 4.0 consortium has taken responsibility for developing the content of all the materials and resources so that they appeal to each of the different target groups. For the Young Minds activities, a gender-balanced approach is taken through, for example, the choice of the workshop content, the contextual approach, how the workshops are organised, and the instructions for the coaches. This allows Young Minds workshops to tackle gender challenges with girls such as the general tendency in girls to lack self-confidence in science and technology, stereotypes about gender roles.

Prof. Averil Macdonald  
OBE from WISE helped us to achieve this goal.

Discover in this booklet how to handle a gender-balanced approach in your fab lab, classroom and other areas.



# PHOTONICS MEETS FAB LABS

The concept of PHABLABS 4.0 is based on combining the World of Photonics with the growing creative ecosystem of existing Fab Labs. A Fab Lab (fabrication laboratory) is a small-scale workshop offering (personal) digital fabrication. A Fab Lab is typically equipped with an array of flexible computer-controlled tools that cover several different length scales and various materials, with the aim to make “almost anything”. Joining forces of top experts from 13 European photonics institutes and STEM-oriented organizations with Fab Lab stakeholders, PHABLABS 4.0 has delivered 33 Photonics workshops, 11 Photonics Challengers and Photonics Toolkits for three different target groups (young minds 10-14y, students 15-18y and young professionals +18y).



## 33 Photonics Workshops

Learning starts with the “Photonics Workshops”. Those creative “Photonics Workshops” enable participants to acquire basic photonics principles, while creating a working device in a short period of time. The workshops are tailored for 3 target groups:

- Young Minds (10-14y),
- Students (15-18y) and
- Young Professionals (+18y).

For example ‘make a laser maze’, ‘art with polarisation’, ‘blinking traffic lights for cyclists’, ‘enhance your cuddly toy with light’ .... You can do all these Photonics Workshops with all the tools from a Fab Lab.

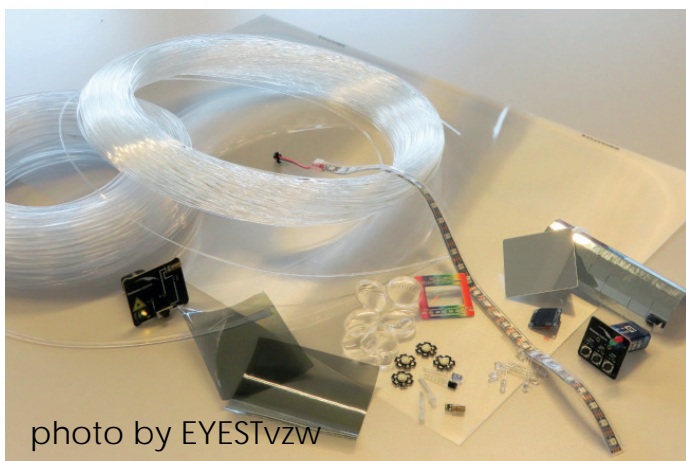
Check out all instructions:  
[http://www.phablabs.eu/  
photonics-workshops](http://www.phablabs.eu/photonics-workshops)

## 11 Photonics Challengers

The “Photonics Challenger Projects” focus on longer term assignments where a practical challenge must be tackled with photonics tools and components, and where creativity is key. Here the role of the instructor is that of a coach. Participants (+15y) will, individually, be equipped to accelerate and deepen their competencies for innovation if they are given easy access to all of the right tools to put their ideas into practice. For example: ‘design a smart lamp which react on your voice’, ‘bake cookies on your home made solar cooker’, ‘let cars communicate via LiFi’, ‘make a hologram of shiny objects’ ....

Find out more about the challengers:  
[http://www.phablabs.eu/  
photonics-challenger-projects](http://www.phablabs.eu/photonics-challenger-projects)





This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Grant Agreement N°.731610

Project duration: 01/12/2016 - 31/05/2019



PHOTONICS<sup>21</sup>

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

### Photonics Toolkits

PHABLABS 4.0 decided to provide complete toolkits for three different workshops. (IRglove, RGB smartphone controlled lamp and GOBO projector). For all other workshops, the photonics materials can be purchased via the website.

<http://b-photonics.eu/en/photonics-toolkit>

# 2.500

These workshops were developed and thoroughly tested in the PHABLABS 4.0 project with more than 2.500 participants.



photo by Fab Lab Graz

# WHY FAB LABS NEED TO BE DIFFERENT FROM EVERYTHING ELSE...

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STEM is missing out on the best talent. For too many years, STEM courses and STEM careers have recruited from a small group – often white, middle class (in the UK) and male. There are three problems with this:

- 1) There aren't enough young people to go round;
  - 2) These people all work in the same way – and group-think is dangerous;
  - 3) A diverse range of people are missing out on the opportunity of a good career in STEM – and that's unfair!
- 

## 1) There aren't enough young people to go round

In most European countries there are fewer young people choosing Science or Engineering careers than we need to fill the high-tech jobs available. This makes it difficult for employers to find enough people with the right skills and therefore the businesses are less successful. There have been many 'schemes' to encourage young people from under-represented groups into STEM careers but with little success. **Fab Labs workshops, organised carefully, can make a BIG DIFFERENCE to increasing the numbers attracted to STEM!**

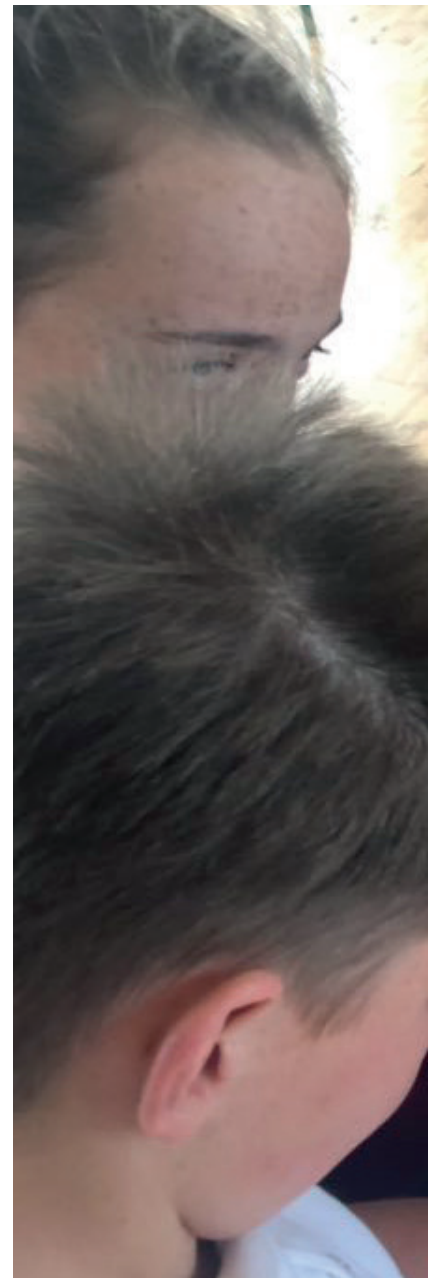
## 2) Group-think is dangerous

A team made up of lots of the 'same type' of people feel they get along really well and that they communicate really easily. This is because they understand each other intuitively. But, the problem is that they won't challenge each other and all their ideas will be similar. This is called 'group-think'. It makes teams less creative – and STEM needs creative teams!

If FAB LABS engage with a diverse range of people, then STEM businesses and universities will be able to attract these same people from diverse backgrounds to work for them. The benefits to businesses and universities are HUGE – more creative and productive science and engineering. **Fab Labs workshops, organised carefully, can make a BIG DIFFERENCE to widening the diversity of people attracted to STEM!**



photo by Tinkerers Fab Lab







*Some argue that setting a quota for women in leading academic positions such as professorships will result in mediocre female candidates being promoted.*

*But there is a gap in reasoning here. Women and men are equally talented, so if men occupy a large majority of high-level posts, there must be an awful lot of mediocrity among their number.*

*Editorial from 'Nature' March 2014.*

<http://www.nature.com/news/science-for-all-1.12535>



photo by Makerspace NUIG





photo by GreenLab

**3) People from under-represented groups are missing out – and that’s unfair**  
Everyone wants to live in a fair world where everyone is able to enter the career they want (and for which they have the ability). For too many years women were banned from entering university, and then were advised to follow careers as secretaries and assistants to scientists instead of being scientists themselves. Things have improved – slowly. BUT it’s clear that people from under-represented groups in STEM have the ability, but are still often discouraged from careers in science or engineering. **Fab Labs workshops, organised carefully, can make a BIG DIFFERENCE to giving under-represented groups access to better opportunities!**



photo by Fab Lab Graz

**//**  
*The institute of Physics in the UK recommends calling females 0-12y 'girls' and 12 year-olds + 'Young women'*  
**//**

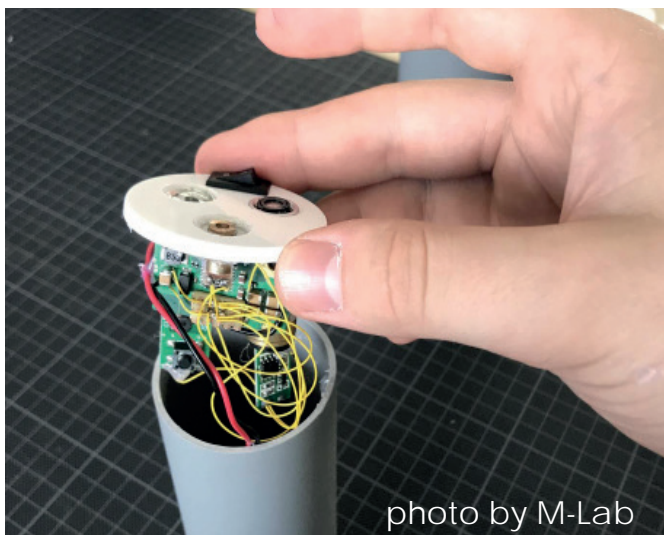


photo by M-Lab

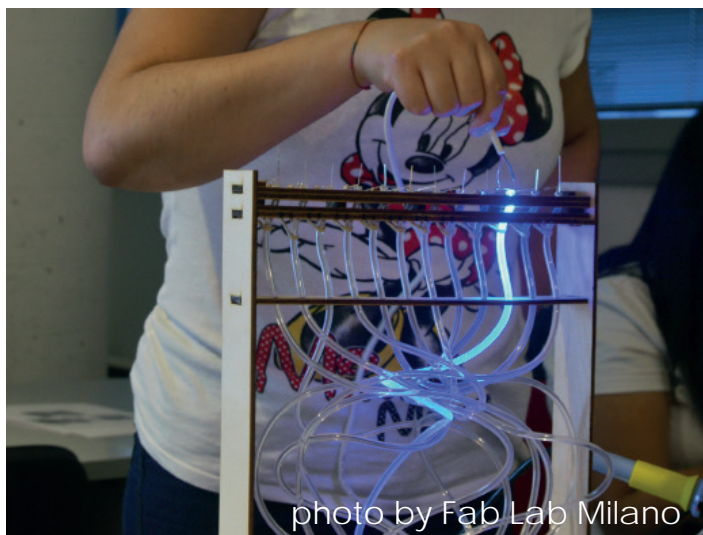


photo by Fab Lab Milano



# WHAT SHOULD FAB LABS DO TO BE DIFFERENT FROM EVERYTHING ELSE...

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There are three key things to remember if FAB LABS are going to make an impact by increasing the number and diversity of people working in STEM careers.

## Remember:

- 1) You can't recruit the best people for a FAB LABS workshop if they don't apply;
  - 2) It's easier to put someone off than to keep them on side;
  - 3) A one-off event won't change minds (or career ambitions) – it's essential to follow up.
- 

## 1) You can't recruit the best people if they don't apply

Your FAB LAB participants aren't like you. You might think you are 'normal', but you're not. We're all different (there's no 'normal'), so you shouldn't base your workshops on what you like – or what you would have liked when you were young. It's not true that 'one size fits all'. So writing your advertising and your workshop activity so that it appeals to you, won't work for everyone.

### Sociology can help:

While everyone is different, Sociology research shows that we are influenced by the world into which we are born and in which we are brought up. People born into different 'generations' have shared values and motivators which affect what they find attractive and motivating in their lives. Understanding these shared values can help us focus on what will engage our audience – and it's not always what engaged us!

### •Born between 1945 - 1960?

You're a baby-boomer and your motivators are hard work, a sense of duty, and the habit of saving up to afford something – you feel you should 'deserve' and 'earn' what you get.

### •Born between 1960 – 1980?

You're a Generation X and your motivators are fascination, work-life balance and to have things now – you don't like to wait as life is too short (which is why Generation X invented credit cards).

### •Born between 1980 – 2000?

You're a Generation Y and your motivators are a desire to be or do something important. Most Gen Y want to be rich and famous and to live in the public eye. They hate being alone and fear being friendless.

### •Born between 2000 – 2012?

You're a Millennial (sometimes called Gen Z). Millennials know they are facing a world with problems and want to change it. They want to make a difference – to make the world a better place. The problem is that this can fill them with guilt and anxiety. (N.B. The evidence is that these dates might be later for countries further East across Europe)

During our Fab lab/ maker education activities, we observe a quite constant difference between children and youngsters (teenagers):

For youngsters, everything is social; who is in the room, can I meet new people/ make new friends, how do I relate to others etc. So focusing on and paying attention to the social, in both topics and work forms etc. is extremely important. Making the world a better place is definitely important, but doing it together might be even more important. Children are relatively more interested in 'cosmopolitan topics'; the earth, space, the environment etc. Sometimes we feel that this very broad range of interests literally narrows down towards themselves and their small range of social contacts during adolescence, after which it is opening up again.

Fab Lab Organiser



photo by Fab Lab Milano

FAB LAB organisers are likely to be Gen X or Gen Y (or possibly a baby boomer). Workshop participants are going to be Gen Z and are going to have different values and motivators from you. So, if you're going to attract and influence your workshops participants to be attracted to STEM careers, you need to understand them and work with what motivates them (and not be distracted by what motivates you!).

**//**  
Our experience is that if you organize workshops where kids come with the school, then the fun factor is important. Young children might be motivated by saving the world but they are self-centered until they are grown up enough and fun is mostly a way to hook them up.

**FAB LABS Organiser**

**It's important to realise that having fun DOES NOT change their mind about the importance of science or whether it's a good career choice. After all they would have fun if you took them to a circus but they wouldn't want to become clowns. Fun is a helpful hook but shouldn't be mistaken for genuine interest. If you are going to make them change their views on science and science careers, you have to appeal to their values and motivators.**

**FAB LABS Advisor**





# HOW TO ATTRACT YOUR PARTICIPANTS

## - IT'S ALL IN THE PREPARATION -

### a) Get to know your participants and design and advertise your activity for your participants:

- Find out more about Gen Z young people;
- Keep in mind Gen Z are motivated by doing good things, and making the world a better place;
- Remember Gen Z aren't driven to do something just because it's 'fascinating';
- Gen Z really prefer being in a group and hate being lonely;
- Gen Z fear most being bored and being friendless; Your adverts and your description of the workshops need to focus on what Gen Z find important. Make it clear that your activity will:
  - Get them to work in a group
  - Allow them to make new friends

- Be exciting
- Show them how science makes the world a better place
- Show them how science can help people – make their lives happier.

### b) Choose your language carefully:

- Use wording in the title and description of a Workshop or a Challenge that focuses on **how it makes the world a better place** – this will make it particularly girl-friendly.
- Include feminine wording alongside masculine wording, e.g. add in lots of adjectives, and use fewer verbs. (See p24.)
- Don't** follow the STEM tradition of using lots of verbs to talk about what scientists and engineers 'do':
  - Don't say "Engineers solve

problems";

- Don't say "Scientists track satellites";
- Don't say "Engineers build bridges";
- etc. etc. etc.

**Do** focus on describing the attributes and attitudes that make good scientists and engineers

Do talk about:

- "Good scientists are naturally careful and organised people;
- "Good scientists are naturally neat, meticulous and conscientious;
- "Good scientists need a good attention to detail and good concentration;
- etc. etc. etc.

**Do** talk about 'he or she', not only about 'he' and not only about 'she'.



photo by Fab Lab Karlsruhe

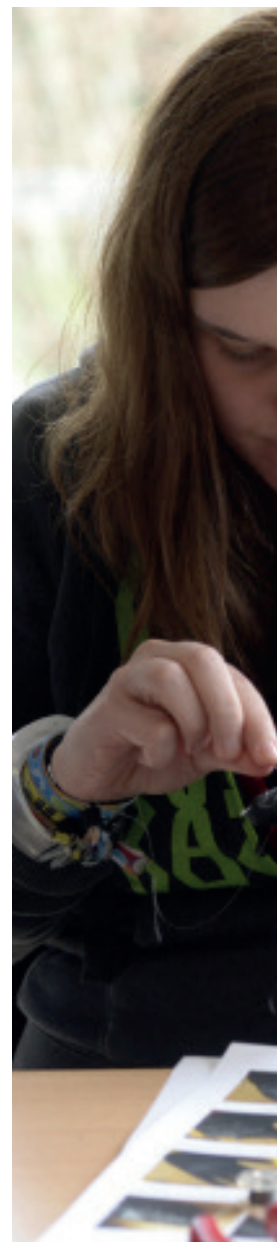
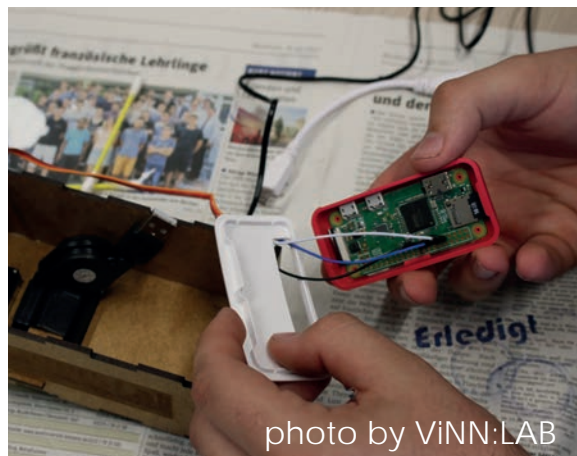
**//**  
*Emphasizing the "so what" and direct impact of the workshop in daily life in the communication activities definitely increases the interest of girls. Above that, girls instead of only boys should be in the photo used to advertise the workshop as well.*  
**Steinbeis 2i GmbH**

**c) Remember that 'a picture paints a thousand words':**

- Show the girls! Use pictures on websites/flyers/banners/posters including lots of girls and under-represented groups to show they are welcome;
- Find female workshop leaders/helpers to show females can be part of the science world;
- Show diversity in the hands or faces in the photographs and movies of the workshops;
- Emphasize the wide range of people who work in STEM careers so that girls will see that they will or do fit in or 'belong'; Make sure they realise they won't be alone.

**d) Working with schools:**

- Require that teachers bring equal numbers of female and male students
- Require that teachers organise follow-up sessions to reinforce what you did.
- Encourage teachers to use the 'Top Tips for Encouraging Girls into STEM' at the end of this resource (See p24).







*Addressing and contacting groups of girls instead of reaching out to them individually is advised, because girls then know right away that they won't be the only girl joining the workshop.*

*Emphasizing that working in a group is possible and that no prior knowledge is necessary to participate to the workshop might lower the hurdle for girls to join the workshop as well."*

**Fab Lab Karlsruhe**



photo by GreenLab



photo by VUB

## 2) It's easier to put someone off than to keep them on side

There's lots of evidence from psychology research that if a participant doesn't feel they 'belong' or are 'welcome' within 20 minutes of arriving in a new place, they will turn off and not come back. This is true for adults joining a new club or gym and for young people trying a new activity or skill. Even if your workshop is really fascinating, if the participants feel 'excluded' or 'unwelcome' or they fear that they will be lonely, you will lose them.

### *Working with your participants:*

#### **a) Start from where the girls are (their self-identity) and what they like. Do not expect them to change into someone just like you:**

- Allow girls to see that they fit into the STEM world – that people like them are happy and successful in STEM;
- Girls prefer to see the application of the technology at the start of the workshop (and not just the fascination or 'how it works');
- Choose the right location for the workshop. Go to places where the girls are and where they feel good, for example: in libraries, schools, youth movement....; This is also true when engaging any under-represented groups!
- Make the output (product) meaningful – building something that makes people's lives better or solves a societal problem;
- Keep things familiar. Offer the chance to use a wide range of machines and tools including familiar 'household' tools e.g. kitchen tools, sewing machine.
- Make sure the girls aren't lonely – make sure that there are several girls who can work together in a group. Organise 'girls only' workshops.
- Suggest that participants share their workshop experience with friends and family on social media.
- Ensure that you look your workshop participants in the eye. Girls and young women respond well to instructors who have a good rapport

with them.

#### **b) Allow under-represented groups to see 'people like me' involved in workshops:**

- Arrange that the workshop is supervised by a woman. She then can fulfil the role of a "role-model" that is not too far away from their world;
- Use role models in posters around the room – make sure that it's not just males in all the photos;
- Make sure the girls aren't lonely or isolated – make sure that there are several girls who can work together. (And don't leave a single girl working with a large group of boys);
- Speak to the girls personally – ask about who they are, not just about what they are doing – and use adjectives to talk about how their aptitudes are valued in STEM careers;
- Make sure you spend as much time with the girls as with the boys – often boys demand more of the organiser's attention and this makes girls feel they aren't important.

**“**  
*Having women be the visible face of the PHABLABS workshops/ challenges automatically breaks the potential initial preconception that some might have that the activity is for men/boys.*

**Lydia Sanmarti – ICFO**

**”**

#### **c) Find a way to embed the technology in everyday life – fabrics rather than metals etc.:**

- Girls respond well to the 'so what' and not just the 'what' – tell them what good the technology can do at the start of the workshop, not at the end;



- “Atmosphere” at the workshop is very important for girls – make the venue the sort of place that girls feel comfortable e.g. make it clean and attractive with plants and pictures and not cold or dirty like a shed. Pay attention that not only “boy stuff” e.g. dinosaurs or computer games are lying around the room.

#### *Writing for your participants:*

Participants need to feel the glow of success. Everything has to be ‘set up’ to make sure they are successful – don’t make them struggle or doubt themselves. Writing instructions carefully can make the difference between participants feeling good about themselves, or feeling the pain of inadequacy and failure. If girls are faced with science information that seems beyond them, they will feel it is their fault and that it is proof that people like them don’t do science.

#### **a) Write instructions at the right knowledge level for participants:**

- Find out what your participants will already know from their school curriculum – don’t assume prior knowledge that they may not have. This is particularly true for younger participants;
- Make sure you provide the background science that they need;
- Explain any new science carefully – avoid jargon.

#### **b) Write Instructions at the right reading level for participants:**

- Younger participants need shorter sentences and shorter words;
- All participants need the instructions set out clearly into well-separated sections – use colour;
- Younger participants respond well to photos as well as words to explain what to do.

#### **c) Lay out the venue to make it comfortable and easy to use:**

- Locate girls near to each other;
- Don’t locate girls near the edge of the groups where they can be ignored by the organiser.
- Provide them with large stickers or wooden pieces, colour market pens and small colourful stickers with which participants can personalize with their name (the workshop facilitators should also do it). This will facilitate calling them by their names, it’s a good ice breaker, and starts the creativity juices going.

#### **d) Write instructions using gender neutral language**

Ensure that your written instructions include he/she and they. (As approximately 3% of the population identify as non-binary it is becoming more common in the UK to use the pronoun ‘they’ even when referring to someone in the singular.)



photo by Fab Lab Erpe-Mere

### 3) A one-off event won't change minds – it's essential to follow up

#### *Following up:*

All businesses realise the importance of keeping your 'product' familiar to your customers. It's the same with STEM careers. You have to remind your participants of what's good about STEM and the opportunities STEM offers.

#### *What next – immediately after the workshop:*

##### **a) Provide information to take away – colourful flyers etc. Careers opportunities are important:**

- Girls respond well to the idea of plenty of choice in their career;
- Girls want to avoid ending up in a 'dead end';
- Emphasise the range of career from STEM qualifications;
- Emphasise that doing science at school won't mean you have to 'be a scientist';
- Emphasise that there are many, many careers in STEM businesses; Point out that science is in many professions beyond laboratories; Emphasise that it's increasingly possible to work part time e.g. after having a family, in STEM related careers. Employers are beginning to realise that finding and training someone is expensive so they want to retain those good people that they already have – and offering good careers' leave and part time work is one way to keep good people.

##### **b) What next – in the following months:**

###### **Working with schools:**

- Get the teachers on side – they are your ambassadors;
- Encourage teachers to adopt girl friendly teaching – see Top Tips for Encouraging Girls into STEM below;
- Encourage teachers to talk about the wide range of careers available from STEM qualifications;
- Encourage teachers not to talk about 'being a scientist' or 'being an engineer';
- Encourage teachers to bring students to another workshop – repeated experiences are valuable.
- Provide teachers with simplified hands on activities to do in the classroom/how to use the prototypes they have created in the classroom.
- Identify science fairs for school children to present the prototypes they have created.

## Check list template

On the following pages we show a short version of a good example of an instruction for the participants!

**N.B. It's essential to write separate sets of instructions for participants and for workshop organisers.**

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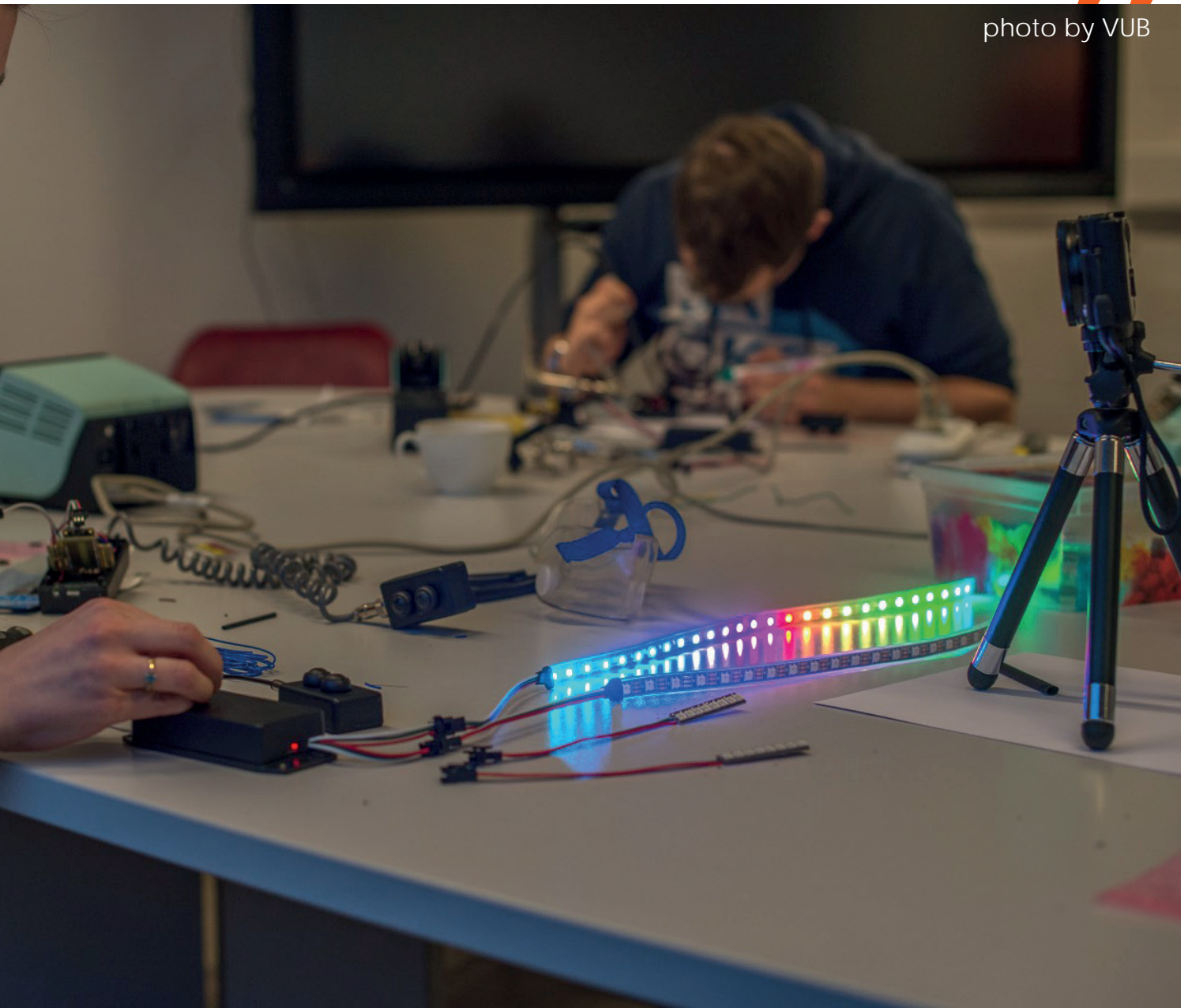
### Never skip a Wrap up!

- *This is when kids present their work and talk about creative thinking, the design process, and solving problems. They also hear about related real-world examples, what engineers do, and how creative problem solving and STEM are relevant beyond the school's walls. In short, the Wrap Up is the time to reinforce key messages.*
- *Move! Don't do the Wrap Up with kids sitting at the tables where they've been building. you can for example go and sit in a circle on the floor.*

**FAB LABS** Organiser

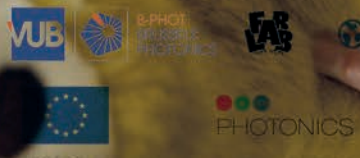


photo by VUB





# Your BEST FRIEND in the dark



01

Why?

"Some young children are afraid of the dark. This is because the child's imagination develops. Fantasy evokes powerful images that only can be controlled when the child can see his surroundings."

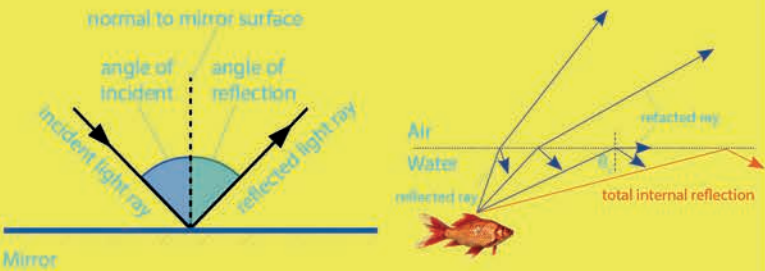


**PURPOSE OF THIS WORKSHOP.**  
Add lights to a toy so that a child who is afraid in the dark can go to sleep happily.



## 02 PHOTONICS TECHNOLOGY

"Reflection on a mirror & on a boundary surface"

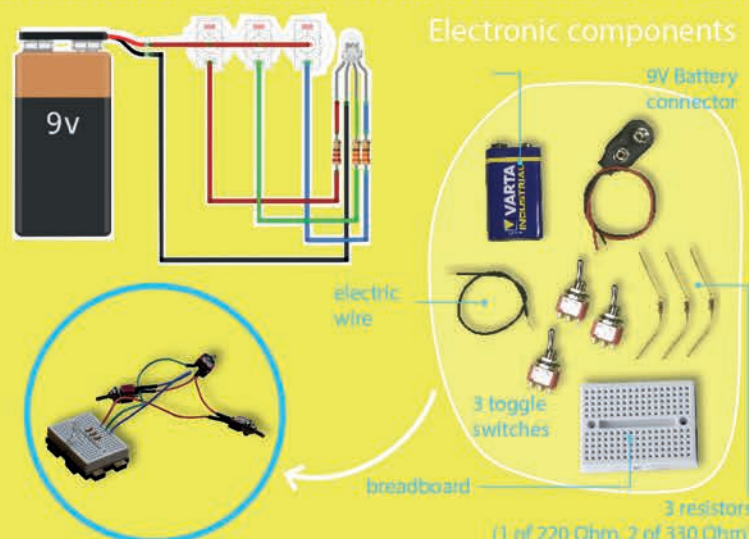
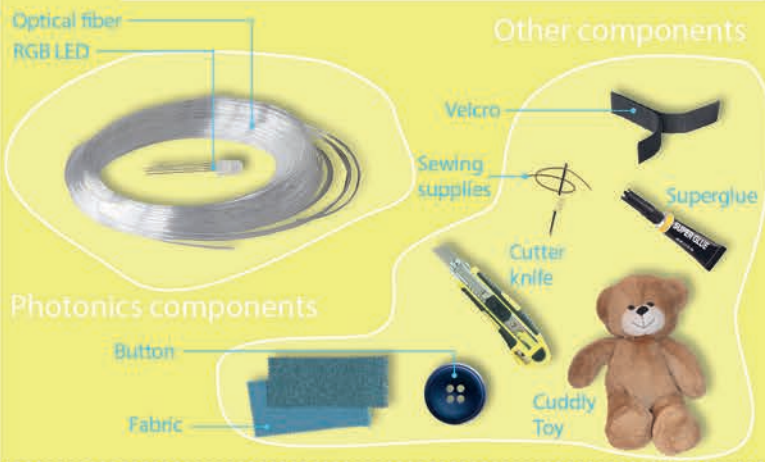


Total internal reflection is the phenomena where light gets reflected inside a particular material over and over again. The angle of incidence is larger than a particular critical angle ( $\theta_c$ ) with respect to the normal to the surface.

"Total internal reflection in optic fibres."



## 03 PART LIST





# CHECK LIST TEMPLATE

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It's essential to write separate sets of instructions for participants and for workshop organisers. Especially in the instructions for the participants, try to make it as attractive as possible for both boys and girls! On the following pages (p20-23) you will find an overview of how the consortium of PHABLABS 4.0 has tackled this and some tips and tricks to do it yourself.

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## Title

Make the title exciting and attractive – think what you'd say if the young person asks "so what?" "What is the point of the exercise?" Don't write a 'factual' title of what the project does. Try to relate it to everyday life.

## Step 1: Why?

Show and explain the purpose of the workshop. Tell the young participants why they should take part in the workshop, highlighting the relevance of the technology and the skills they will be using to the wider world.

Indicate clearly:

- the prior knowledge and understanding of optical concepts that participants will have before they arrive – check that this is a reasonable expectation based on the target age of the participants.
- The age of the target group.
- The tools needed from the Fab Lab
- The time they will need to perform the workshop.

## Step 2: Photonics technology

Indicate clearly the science learning (knowledge and understanding of optical concepts) that will take place as a result of the activity.

Use explanatory drawings and/or diagrams and if possible foresee a small experiment that the target group can do by themselves.

## Step 3: Part list

Take photos of the different types of parts needed for your workshop.

Name the different types of materials needed for this workshop.

Divide them in three main groups: the photonics parts, the electronic parts and the other parts needed to perform this workshop.

If necessary, include where they can obtain this material.

Use as many pictures as possible, including photos of people from under-represented groups.



*I think there is a golden missing rule here: iconographics! we give hundreds of workshop per year to children between 5 and 14, and one thing is sure they DO NOT READ! use drawings and as little text as possible. This is very challenging, but reading just doesn't go quick enough for them.*

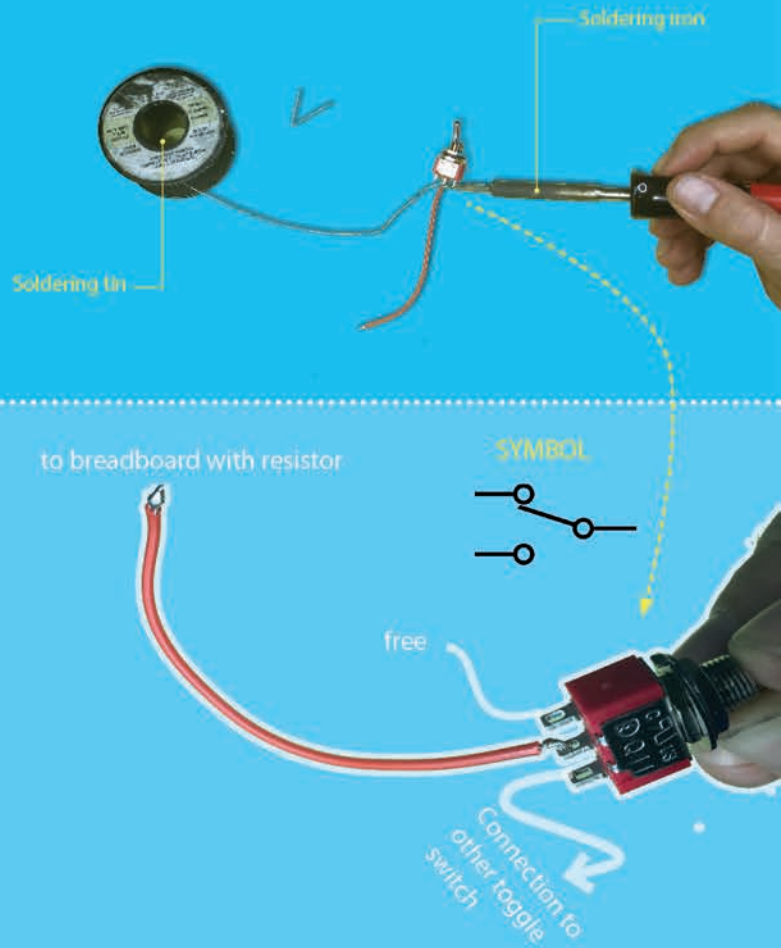
**FAB LABS** Organiser



# 04 IMPLEMENTING OPTICAL FIBERS



# 05 SOLDERING



# 06 APPLICATIONS IN REAL LIFE



"Short light flashes, internet, are send through optical fibres over thousands of kilometres. A single cable lying on the ground of the sea, can send 10 TB data per second."

# 07 PHABLABS 4.0



[www.phabblabs.eu](http://www.phabblabs.eu)

Youtube step by step






Ethernet cable  
speed: 0.1 Gb/s

66 min



Download blu-ray disc  
50GB = 400Gb



Optic fiber cable  
speed: 1000 Gb/s

0.4 s



PHOTONICS<sup>21</sup>

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

ORIGINAL DESIGN BY **Iaac** FAB LAB BARCELONA



### Step 4 - 5: All steps needed for the workshop

In the following steps you will describe how to make the end product. If necessary, make a division between the basic workshop and an extension of the workshop.

If the instructions are intended for workshop leaders, explain how to demonstrate the various steps and highlight any difficulties participants might encounter.

If the instructions are intended for the workshop participants to use directly, make sure every step is clearly laid out with particular emphasis on explaining what to do if things go wrong.

Don't forget to archive each step with photos.

If more technical explanation is needed for the target group, don't forget to make explanatory drawings and/or diagrams. Include an electrical scheme whenever this is needed. (These can be made in Fritzing.org).

This example only shows two steps (step 4 & 5), of course there are more steps. This is only a flavour of how the PHABLABS 4.0 consortium has done it. You can find all complete examples online on the Phablabs 4.0 website:

<http://www.phablabs.eu/photronics-workshops>

### Step 6: Applications in real life

In this part you can provide more information on the technology of light used in this workshop.

It is a good idea to talk about applications of this technology in real life;

It is a good idea to talk about different careers available that rely on this technology. This is particularly important for girls and should include a very wide range of careers and not just bench-based engineer;

For older workshop participants, it is a good idea to mention qualifications and study routes that are available.

### Step 7: PHABLABS 4.0

Show where the participants can find more information about the workshop.

For example: links to videos, links to the more descriptive instruction.


### Follow up:

Offer ideas for students to follow up.

Hand out flyers of information and 'case studies' of successful females in STEM;

Links to useful websites for activities or careers;

How to join another FAB LAB workshop or become active in the FAB LAB community.



*For the gender question, that is, in which way we attracted girls in fab lab we increased the number of female mentors, we developed activities with STEAM approach, we tried to balance the offer trying to intertwine design and technology.*

**MUSE FAB LAB**



# TOP TIPS FOR ENCOURAGING GIRLS TO CONSIDER STEM CAREERS

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Girls are more likely to consider studying STEM subjects beyond age 16 if:

- they see that the subject keeps their options open;
- they can envisage themselves working in that area;
- they consider that they will 'fit in' – they will be working with people like them.

Research shows that a barrier to girls choosing STEM careers is the conflict between their emerging self-identity and their perception of the STEM-identity and if they can't resolve this conflict, they fear that they won't 'fit in' and then look elsewhere. This starts from round age 10.

We know that certain words such as verbs and masculine adjectives reinforce the self-identity: STEM- identity conflict and put girls off while more feminine adjectives will attract far more positive attention.

The sense of fitting in can be reinforced by careful choice of vocabulary and messages during lessons. Make sure you use a good mix of adjectives.

---

## Feminine adjectives

Cheerful Committed Communal  
Connected Considerate Cooperative  
Dependable Empathic Honest  
Interpersonal Interdependent Kind  
Loyal Modest Nurturing People-focused  
Pleasant Polite Quiet Responsible  
Sensitive Supporting Sympathetic  
Trustworthy Understanding Warm

## Masculine adjectives

Active Adventurous Ambitious Analytical  
Assertive Connected Autonomous  
Challenging Competent Confident  
Courageous Decisive Determined  
Dominant Forceful Impulsive Independent  
Individual Intellectual Leader Logical  
Merit Objective Opinionated Outspoken  
Persistent Principled Superior Self-  
confident Self-sufficient Self-reliant





It's not just language, there are many things that help a girl see herself as potentially working in a STEM business.

## So what works?

### Do

- Do emphasise that there are huge numbers of jobs – all different – that rely on science qualifications, so science keeps options open and gives them more choice.
- Do emphasise that people working in STEM companies routinely have a very good salary and career opportunities and earn far more than people in the 5C's – cleaning, catering, clerical, cash-iering, caring.
- Do emphasise that there are large numbers of tech focused companies and organisations in the EU needing people with science qualifications for business focused roles.  
Do talk about apprenticeships or technical qualifications.
- Do describe the aptitudes that tech companies are looking for (using adjectives) so that girls can recognise themselves in the description.
- Do explain that tech companies have family friendly policies and the opportunity for part-time and flexible working so they can look forward to a career break and/or flexible working without losing out on promotion opportunities.
- Do realise that many girls will be out of their comfort zone and will need to express their feelings and should be encouraged to realise they can be successful in physics without losing their femininity.

### Don't

- Don't talk about 'being a scientist' or 'being an engineering' as this implies a very narrow range of options – talk about careers FROM science and maths qualifications.
- Don't just talk about what scientists 'do' using verbs, - also talk about the aptitudes they need using adjectives.
- Don't imply that STEM careers are only for 'the brightest' or for those who will get top grades in exams.
- Don't talk about companies particularly seeking applications from women as some people feel that this implies girls will be looked on by colleagues as being appointed not because they were the best but because they are female.
- Don't talk only about 'high powered' careers as if there are no roles other than these – include support roles too.
- Don't make comments that suggest it's unusual for girls to be interested in Physics or that boys are naturally better than girls at physics.

# GIRL-FRIENDLY STEM TEACHING

- Do make the lesson as collaborative and interactive as possible, engaging all students in activities and discussion.
- Do use age-relevant, gender neutral metaphors and examples such as a bus or the school building.
- Do find everyday language, and encourage students to use it until comfortable, then define physics specific meanings deliberately.
- Do put things into context, give examples from everyday life both applications and careers.
- Don't plan lessons in which students only look and listen and are not allowed to touch or talk.
- Don't use metaphors or examples which may exclude girls e.g. rugby, cricket, firearms.
- Don't use scientific language too early in the introduction of a concept – and encourage students to keep a vocabulary section at the back of their book to remind them of new words.
- Don't assume students automatically understand the 'big picture'.





# USEFUL LINKS

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<http://www.girlfriendlyphysics.co.uk/>

<https://www.wisecampaign.org.uk/resources>

<https://www.wisecampaign.org.uk/resources/2014/11/not-for-people-like-me>

<http://www.sciencecouncil.org/10-types-scientist>

[http://www.iop.org/publications/iop/2012/page\\_58292.html](http://www.iop.org/publications/iop/2012/page_58292.html)

[http://www.iop.org/education/teacher/support/girls\\_physics/opening-doors/page\\_63803.html](http://www.iop.org/education/teacher/support/girls_physics/opening-doors/page_63803.html)

[https://docs.google.com/document/d/1\\_WsEzKa4oUCJT6UoQy\\_oikemtTMuQQ696sYMfHyt9q8/edit](https://docs.google.com/document/d/1_WsEzKa4oUCJT6UoQy_oikemtTMuQQ696sYMfHyt9q8/edit)

<https://drive.google.com/open?id=1Pt3Bnlb7YOa-SzPYmrGJFtZA2vc5ckeF>

<http://www.phablabs.eu/>

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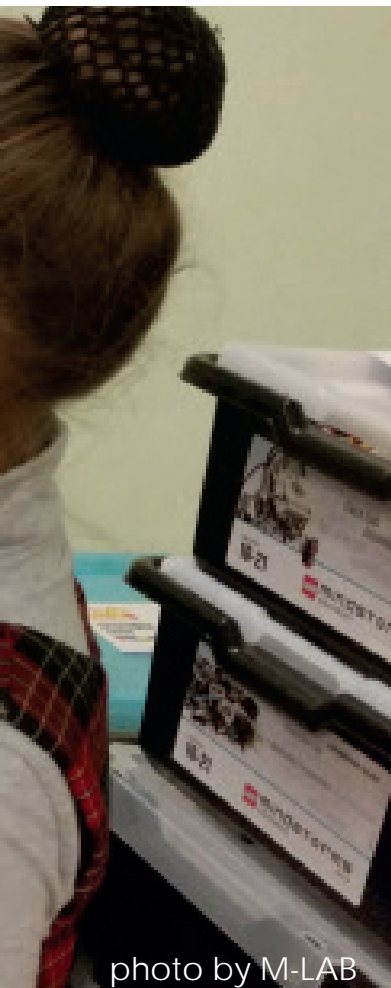


photo by M-LAB

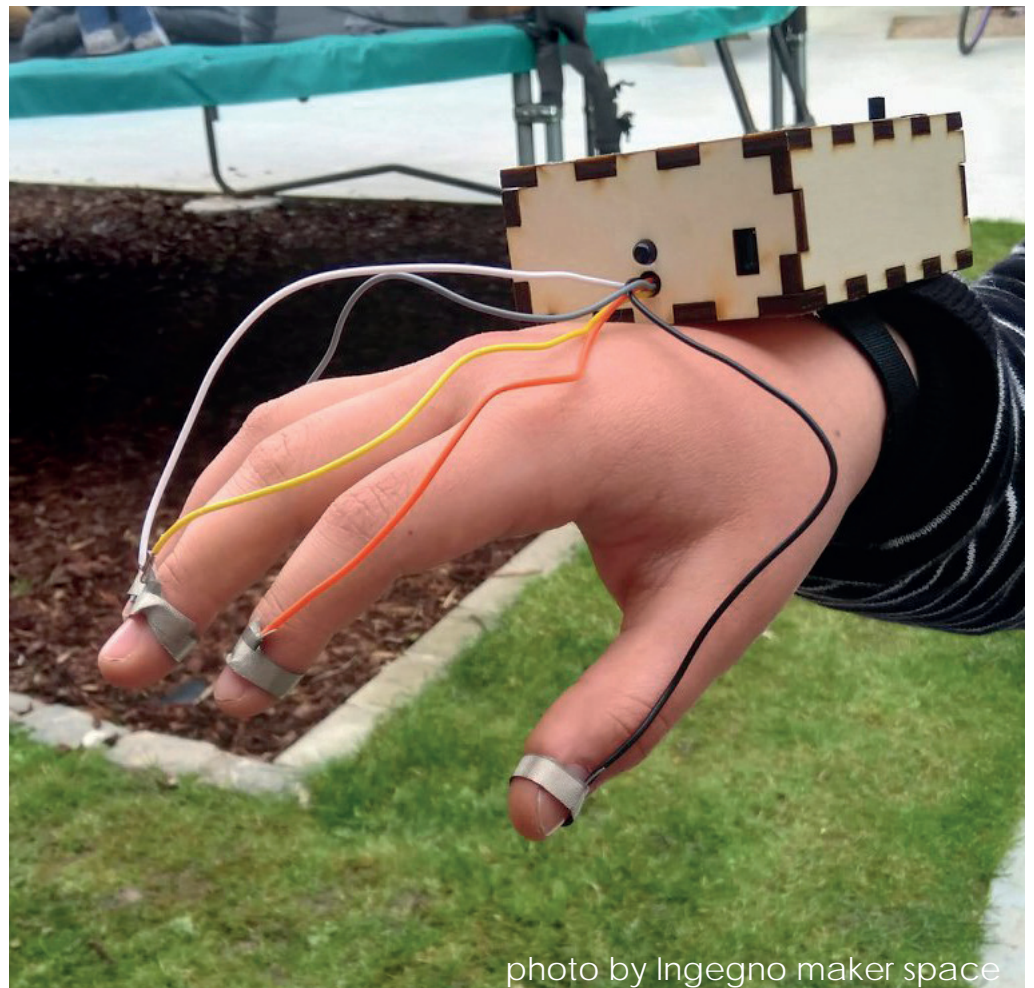


photo by Ingegno maker space

# UNCONSCIOUS BIAS - are we unconsciously putting the girls off?

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We all have a 'fast thinking brain' and a 'slow thinking brain'.

Your 'fast thinking brain' processes via short cuts – it looks for patterns and tries to fit new things into 'boxes' that it has created (from things it has learned throughout your life). We evolved our fast thinking brains as 'cavepeople' in order to make decisions quickly so that we could survive. You can tell when someone uses their fast thinking brain as they talk about 'jumping to conclusions' or 'knowing intuitively' or 'gut reaction'.

Your modern, evolved, 'slow thinking brain' likes to process information carefully and to draw logical conclusions based on information and data. It takes longer and uses more energy than using your fast thinking brain. Science has to be done by your 'slow thinking brain'.

Using our fast thinking brain can lead us to 'unconscious bias' in our thinking about

people, and this can affect our decisions and behavior – and can lead us to being unfair in our judgements of people and how well they are suited to a career in STEM.

However, we can use our modern, slow thinking brain to control our caveperson, fast thinking brain. We can increase our awareness of strategies to manage our brain's short cuts to avoid poor decision making.

For example if you ask a child to draw a professor they will almost always draw an elderly, white man in a white coat who may look like Einstein. The child has been influenced by things in their short life (TV, comics) and has created a 'box' in their head marked 'professor', and this is what they draw. A problem arises when the box marked professor, with all its stereotypes, leads us to make decisions that are not reliable, such as 'only elderly, white men can be professors'.



***I was talking to the plumber about this – and she said that she finds the same thing....***

***...and as soon as I said 'she' you all went 'oop' inside, didn't you?***

***That's unconscious bias.***

***And you can't help yourself, it's because in your lifetime you have almost always associated plumber with 'male' – the plumber 'box' in your head is male. So when you are faced with a female plumber your fast thinking 'caveperson' brain looks at the 'box' and makes you go 'oop' because the female plumber doesn't fit.***

***You know logically that plumbers can be female. But your fast thinking brain cuts in immediately, and your modern 'slow thinking' brain comes in later to say 'actually plumbers can be female'.***







The point of unconscious bias training is not to stop your fast thinking 'caveperson' brain – you can't do that - but to train your modern, evolved brain to override the gut reaction of your caveperson brain so that you don't make dubious decisions, based on your gut reaction, and instead make decisions based on logic and fact. For example there is evidence of a gender bias in appointing staff. If the same CV is sent, but with randomly a male or a female name on it, hiring managers will be far more likely to appoint the 'male' candidate and to offer him more money than the 'female' candidate.

*There are 2 possible explanations:*

- Managers are consciously biased and deliberately choose the male candidate because they want a man regardless of whether a female candidate is better.
- Managers are biased in their decisions because they perceive men as naturally better candidates, but they are unaware they were doing it. This is unconscious bias.

It could be that people are genuinely biased against females or that they are biased and unaware – that means that their caveperson brain is taking the lead in the decision making, which leads to poor (biased) decisions.

*Explanation from Psychology:*

Unconscious bias refers to a bias that we are unaware of, and which happens outside of our control. It is a bias that happens automatically and is triggered by our brain making quick judgments and assessments of people and situations, influenced by our background, cultural environment and personal experiences. (ECU: 2013 Unconscious bias in higher education)

*Explanation from evolution:*

We automatically make a 100 microsecond judgement of everyone we see. (Friend or foe, level of attractiveness, dominant or not...) and neuroscience says that our caveperson brain makes 200,000 operations for every single 'thought' made by our modern brain.

This means it's very easy to default to a decision based on first impressions which can be biased. This leads to poor decisions rather than well considered decisions.

*Conclusion*

All people have the fast thinking, gut reaction (caveperson) brain for survival that is based upon our 'mental boxes' (the boxes we have created in our minds based upon our personal experience and which we use to 'categorise' people).

All people also have the slow thinking modern brain that bases decisions on fact and logic – a much more reliable way to make decisions.

# WHAT TRIGGERS UNCONSCIOUS BIAS?

Characteristics that might elicit an unconscious bias response.

Gender	School
Ethnicity	Accent
Religion/belief	Clothing
Perceived sexual orientation	Haircut
Attractiveness	Body language
Age	Personality
Disability	Family/friends

## Risk in working with young people

*"She doesn't look right/ he doesn't sound right"*

We can be influenced to decide a student is not good at Science, even if they do well, if they don't look right or sound right.

Unconscious bias leads us to say:

- If a student does well or badly in line with our expectations, we say 'we were right all along!'
- If a student does well or badly against our expectations, we say it's 'a blip'

*"Biased Selection Tests"*

Tests 'select' the same types each time. Our selection tests can lead to risky or dubious decisions. Often they are designed to choose someone who is a replica of the people already in place – e.g. engineering selection tests are often designed to choose white males!

*"Stereotype Threat"*

Students underperform if they are told that people like them do badly in certain tasks e.g. girls and maths, then they will perform worse than they would otherwise.

*"Diligence vs Unschooled Genius"*

In the UK there's a literary 'motif' which is based on the idea of the unschooled male genius e.g. Sherlock or Harry Potter whereas

if a girl does well we assign that to 'hard work' e.g. Hermione Granger. This leads to people encouraging a boy more than a girl as there's an assumption that there's still more to come whereas for a girl there's the assumption that she has already peaked.

*"Minority effect"*

If a minority group is less than 30 % of the group total, they underperform.

*"Teacher Expectations"*

- Bias in assessment of students' aptitude for science (Spear, M., 1987)
- The biasing influence of pupil sex in a science marking exercise. In A. Kelly (Ed.), Science for Girls? (pp. 46-51). Milton Keynes: Open University Press.



photo by Fab Lab Erpe-Mere



These are examples of research that show that even teachers can be biased in their assumptions of who is suitable to study science. In the second one the teachers are asked to mark homework with either a male or female name on it and always give more marks to the 'male'.

N.B. the point of showing this research evidence is that lots of people will either not believe or will dismiss these stories as anecdotes. The point of research is to show that the effect is replicated enough times to be worrying.

And it's also important to realise that it's not just about marking. Teachers of science are often less able to engage with the girls in such a way as to enable the girls to feel that science is 'for people like them'.

### *Summary:*

- We all have unconscious biases and we are all affected by bias – it's our fast thinking brain.
- We can take action to manage the impact on our behaviour, relationships and decision making.
- When working with young people it is essential to use our slow thinking brain to overcome any biases we have so that we do not inadvertently discourage girls from taking science.



photo by Astertechnics

# RESULTS OF THE GENDER-BALANCED APPROACH IN THE PHABLABS 4.0 PROJECT

The PHABLABS 4.0 consortium has taken responsibility for developing the content of all the materials and resources so that they appeal to each of the different target groups. For the Young Minds activities, a gender-balanced approach is taken through, for example, the choice of the workshop content, the contextual approach, how the workshops are organised, and the instructions for the coaches. This allows Young Minds workshops to tackle gender challenges with girls such as the general tendency in girls to lack self-confidence in science and technology, stereotypes about gender roles.

## Measuring impact

The PHABLABS 4.0 consortium looked to measure the impact of the gain in acquired knowledge and skills of the participants in the photonics-enhanced Fab Labs as well as the impact the workshops had on the girls.

Therefore, the participants of the Photonics Workshops (at least 2200) have been asked to complete a survey both before and after this activity. We focused the evaluation forms on the impact they have on the

mindset of the participants regarding science and their future work.

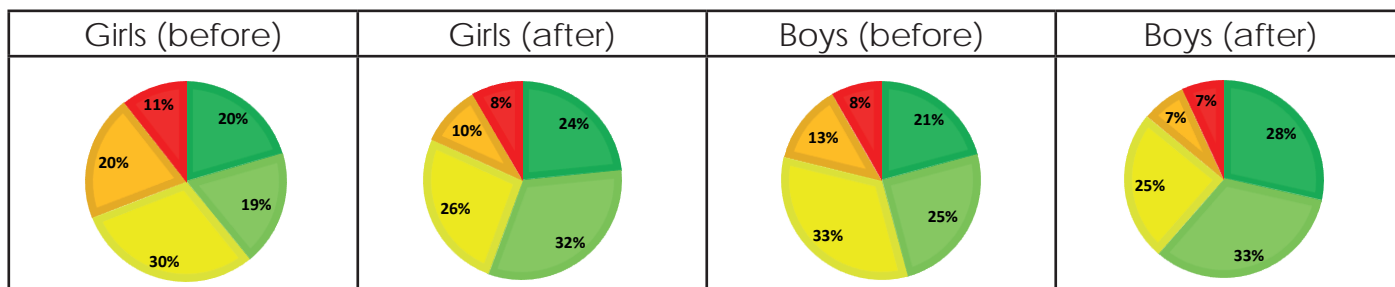
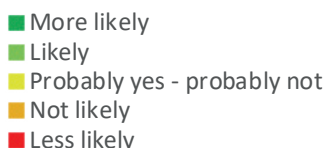
The results of the feedback forms of the participants show in general a very positive effect of the PHABLABS 4.0 workshops. And it seems that the impact is the highest with the youngest target group. We can conclude from this that this gender-balanced approach works.

On this and the next page you can find some of the obtained results during the project period.

### Young minds (10-14y)

The conclusions below are based on 1162 (503 girls and 618 boys) completed surveys by participants of the Photonics Workshops.

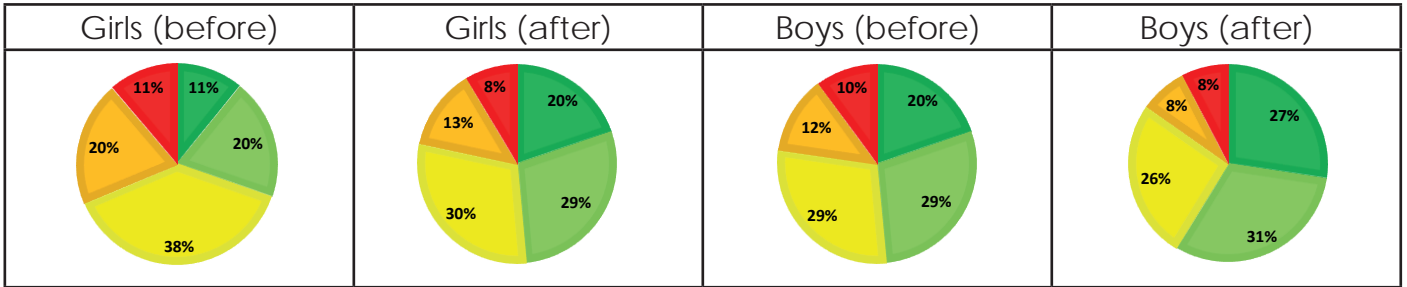
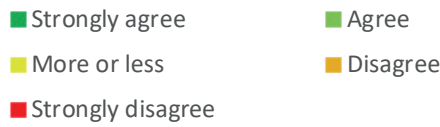
*Can you imagine yourself working in a science or technology business?*



The PHABLABS 4.0 workshops have a positive influence on the likelihood of the participants to work in a scientific or technologic environment. We saw a significant increase with the girls.



*I believe I can be successful in a career in engineering?*

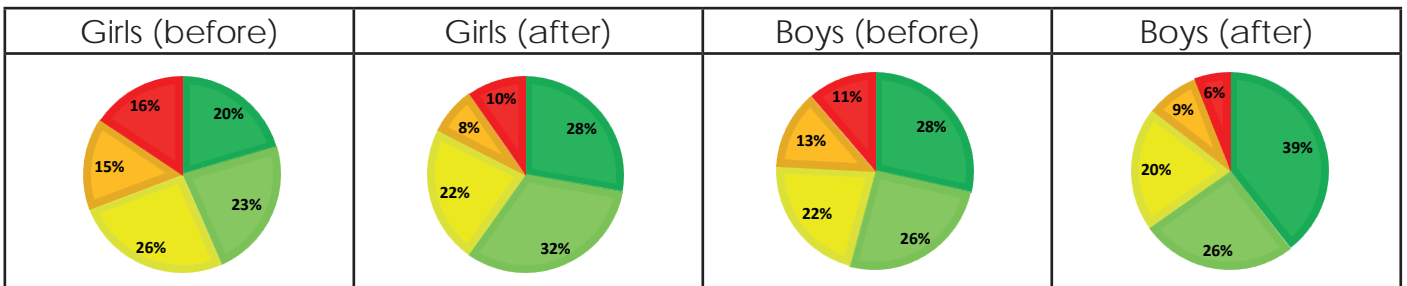
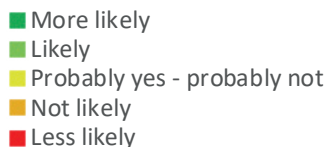


Here we can see a big difference between boys and girls. Boys are more self-confident in their engineering skill before the workshops. But the workshops convince very many girls in their abilities to successfully pursue a career in engineering.

*Students (15-18y)*

The conclusions below are based on 946 (355 girls and 559 boys) completed surveys by participants of the Photonics Workshops.

*Do you plan to study STEM after age 18?*



The workshops have a small impact with respect to convincing more boys to study STEM. However the workshops turn out to be a great stimulus to convince girls to study STEM-related curricula.

For most of the participants it was their first experience in a fab lab and a very high percentage would recommend it to their friends, which shows that the participants very much like the Photonics workshops in the Fab Lab.

# PHOTONICS TOOLKITS

*Get started, create a prototype and learn about photonics technology!*

A total of 33 Photonics workshops, tailored to three different target groups, are developed to be performed in **Fab Labs**. At the same time they can also serve as excellent **STEM-projects** with your students at school. B-PHOTONICS decided to provide complete toolkits for three different workshops. For all other workshops, the photonics materials can be purchased via the website.



## Photonics components

In the general photonics toolkit you can find all the specific photonics components needed for the 33 Phablabs 4.0 workshops. Select the components you need and B-PHOTONICS will send you a quote for it. Most components come in sets of five pieces.

Some of the components available on the website:

- *Flexible and rigid plastic optical fibres*

Make a Photonics Piano or add light to a toy so that a child who is afraid in the dark can go to sleep easily.



- *Polarisation foil*

A polarizer is an optical filter that lets light waves of a specific polarization pass and blocks light waves of other polarizations. Make art with polarization where the colours change when turning the piece of art or measure the amount of sugar in your drinks with a polarimeter.



### • Eye-safe lasers

Stop the burglars! Make your own version of the laser maze. Use mirrors, beam splitters and your brain to guide the laser rays through the maze and guard your own treasure!



In addition, 3 complete toolkits (photonics+other parts) identified as ideal STEM projects by teachers targeting the needs of schools are also made available commercially.

### Infrared Glove



Build a DIY-remote-control-glove. By bringing two fingers together, you can command a robot to stop, go or change directions. You will learn to implement electronic components and drive them using Arduino. At the same time, you will learn about infrared technology.



15-18y

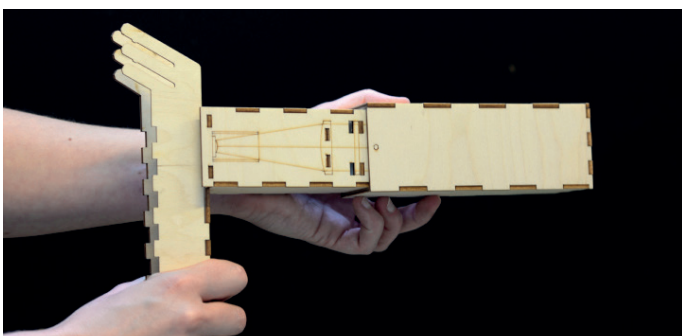


6h



€25/IRglove

### GOBO Projector



The photonics Gobo slide projector is composed of various parts shaped from wood with a laser cutter. The power LED and the two lenses make it possible to project a figure or drawing made on a plate. The distance between the two lenses can be adapted to change the size and focus of the image.



10-16y



2h



€12,5/projector

### RGB Smartphone controlled lamp



With this photonics toolkit you can make a powerful RGB lamp. The intensity of each colour is controlled by your smartphone. This can be completed in a 2.5-hour workshop, thanks to the included breadboards that significantly reduce the amount of time spent on soldering. This is a great project that perfectly fits with studying the Internet-of-things!



15-18y



2,5h



€23/lamp

More information or forms to ask for a quote via: <http://b-photonics.eu/en/photonics-toolkit>

**B-PHOTONICS**  
INSPIRING THE NEXT GENERATION

## Contact us for more information:

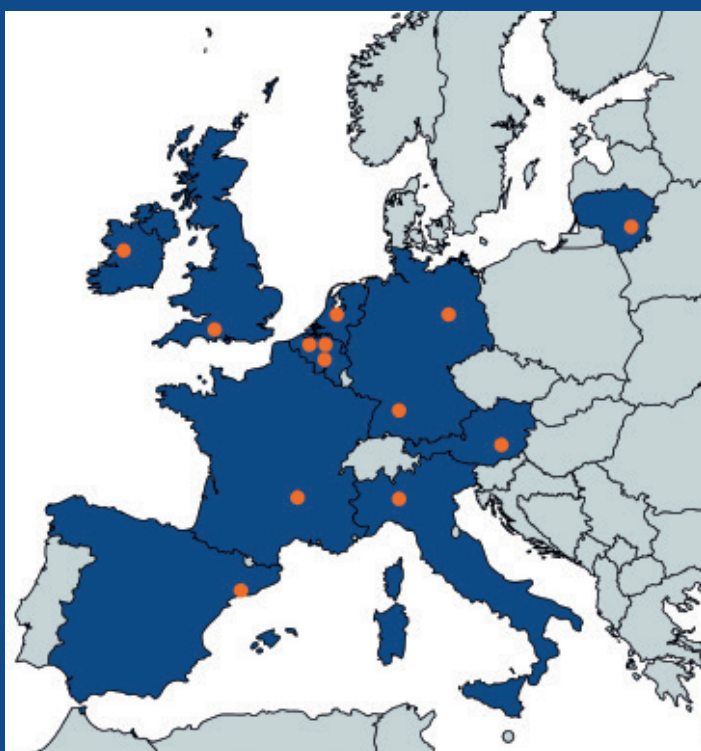
[www.phablabs.eu](http://www.phablabs.eu)

[phablabs4.0@gmail.com](mailto:phablabs4.0@gmail.com)



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