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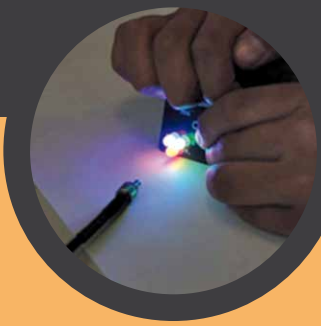

Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH,
Institute for Photonics and Nanotechnology
of the National Research Council (Ed.)

Towards Best Practice in Photonics Outreach for Young People

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

PHOTONICS21

Photonics4All
Discover the Power of Light

Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH,
Institute for Photonics and Nanotechnology of the National Research Council (Ed.)
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Foreword

Optics and *photonics* are widely regarded today as key technologies. Many science and technology experts have described the 21st century as the century of the photon because optics and photonics technologies are providing science and industry with a wide-range of essential applications impacting nearly all areas of our lives! In fact, Photonics has been recognized as a *Key Enabling Technology* (KET) by the European Commission in a Communication[1] dating back to 2009. However, despite its importance photonics is still not a well-known technology to a majority of people.

This handbook is devoted to all those public and private organisations willing to organize outreach activities for young people. In particular, we address universities, research centres, science centres, museums that have outreach at the core of their activity, and also city councils, regional administrations and national governments interested in the promotion of scientific knowledge to young children.

The objective of this handbook is to *summarize best practices on how to promote photonics and light-based technologies to young people*. We hope that our experiences in the Photonics4All project will serve all those interested as a useful inspiration and guide when promoting photonics. The handbook is not meant to be authoritative, nor exhaustive in terms of photonics outreach, which is why we decided to publish this document with the title 'Towards Best Practice in Photonics Outreach', but we hope it provides an overview of the best working approaches undertaken in the Photonics4All project and benefits the network of science communicators throughout Europe. The handbook should be relevant to all those interested in outreach, whether newcomers or more experienced science communicators. Please pick and choose the elements that are relevant for your own outreach activity. The text in this handbook is accompanied by practical and user-friendly information in the annex; pages of which can be printed out individually. Policy makers too can also find relevant information in the conclusions at the end of the booklet.

1 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52009DC0512&from=EN

Please note that two other handbooks are also available in this series, one on photonics outreach activities targeted at entrepreneurs, and a second one on best practices to increase the general public's awareness of Photonics.

Photonics4All Consortium,
December 2016

Acknowledgements

A number of partners have contributed to this publication throughout the project; from the initial proposal of good practices, to the selection of topics and to the final product. We would like to thank the European Commission and Photonics21 for the promotion of the project “Photonics4All“ under the EU program “Horizon 2020“ for research and Innovation, along with our partners who have supported our work during the lifetime of the project. We would like particularly to thank our sister projects “GoPhoton!” and “Light2015” for sharing their best practice in how to increase awareness of photonics, one of those (“LIGHTtalks”) being included in this handbook.

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1 Introduction

The following outreach tools and activities developed and delivered in the Photonics4All project, along with those of our partners, are covered in the handbook; a Photonics App, Photonics Games, a Photonics Animated Video, Photonics Children's Universities, Photonics Teacher Training Sessions and other Photonics Outreach activities. In each section which describes the activity or tool we include the following; a description of each activity, an outline of the intended target groups, how the event was organised / the tool developed, along with methods to assess the impact of each type of activity, and our experiences and recommendations of delivering the activity or working with the tool. At the end of the handbook are Annexes which detail event planning tools, contact details for each partner (Annex 7) – all of whom can be contacted for further information), along with a short description of the Photonics4All project (Annex 6).

2 Photonics App

Objective: The Photonics4all App was developed primarily to promote an understanding of, and enthusiasm for, photonics amongst young people (using technologies that appeal to them i. e. their smartphones and tablets), however the App is also suitable for the young people's parents, the wider general public and for teachers too.

The App covers basic information about photonics through the interactive and fun games / activities included in the App.

Target group: children (pupils aged 12–18)

Organisation: This section will cover first an overview of the App Contents, secondly, the method used to produce the App, thirdly the App development, fourthly, links to the App itself and lastly how the App has been promoted to date.

An overview of the App contents:

The completed Photonics4All-App contains five different modules:

- Module 1 : Basics Photonics Concepts
- Module 2 : Photonics for ICT
- Module 3 : Photonics for Health and Life Science
- Module 4 : Photonics for Energy, Lighting and Display
- Module 5 : Photonics for Security, Metrology and Sensors

Each module contains a number of chapters, each of which includes explanations of a particular concept. Each chapter is organized in three sections, or steps, the knowledge in which builds on the preceding step:

- Understand: In this step, a photonics concept is explained as simply as possible.
- Experiment: In this step, simulations or animations are used in order to demonstrate the concept.
- Quiz: In this step, the App user can test whether they understand the concept or not (The quiz contains a maximum of three questions).

Method: At the beginning of the App project Opticsvalley created a document with specifications for the App which was sent to eight, selected external partners (schools and companies) in order to look for external partners willing to create the App.

After an analysis of the received proposals, Opticsvalley selected one school: ESIEE (Paris School of Engineers for Innovation) to provide the operational structure for the App, in partnership with IOGS (Institut d'Optique Graduate School) who proposed to provide the technical content.

Opticsvalley followed the work developed by these schools very closely, providing a lot of input into the design and content of the App in order to arrive at a satisfactory result.

The final Photonics4All App can now be downloaded on Google Play Store[2].

A web version has also been developed which can be found at: www.photonics 4all-app.eu. This second development was designed to increase the App's visibility and more than 700 visits to the App have been made after only 4 weeks online.

Development: The content structure and homepage view of the completed App is shown below along with sample pages:

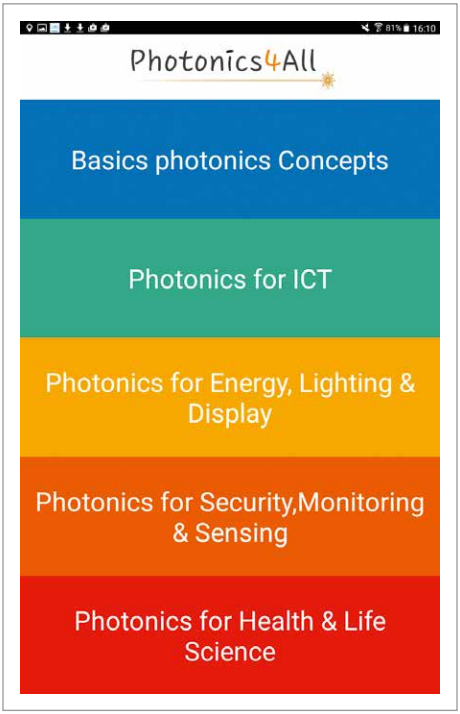
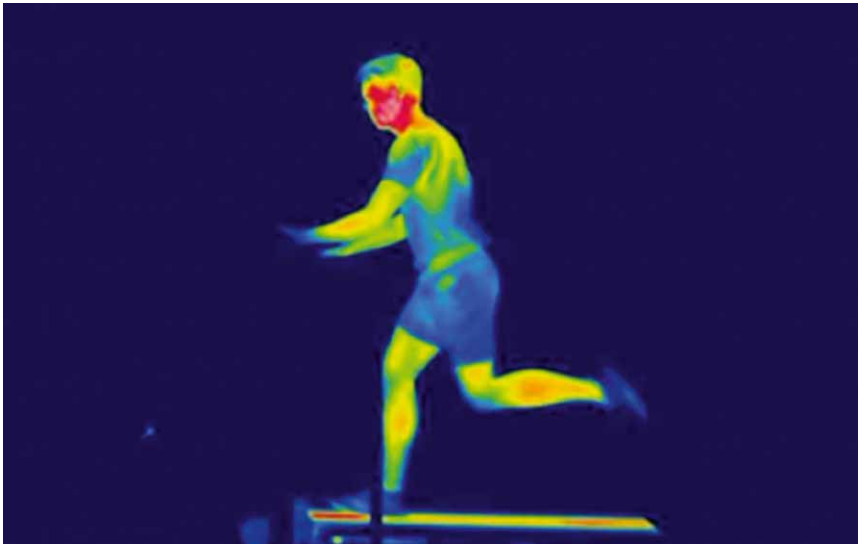
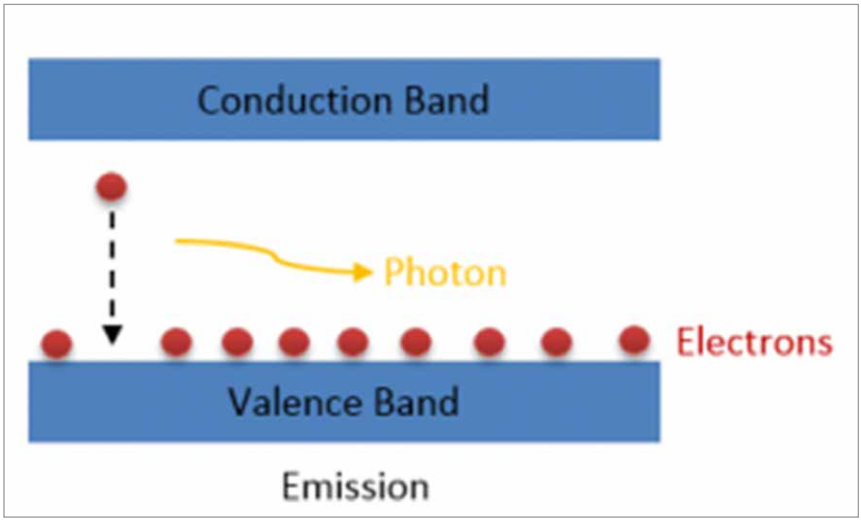


Figure 1: View of App homepage.
Source: Optics Valley

2 https://play.google.com/store/apps/details?id=esiee.android.nevyan.photonicsforall&hl=de

Examples: Screenshots of the App contents:





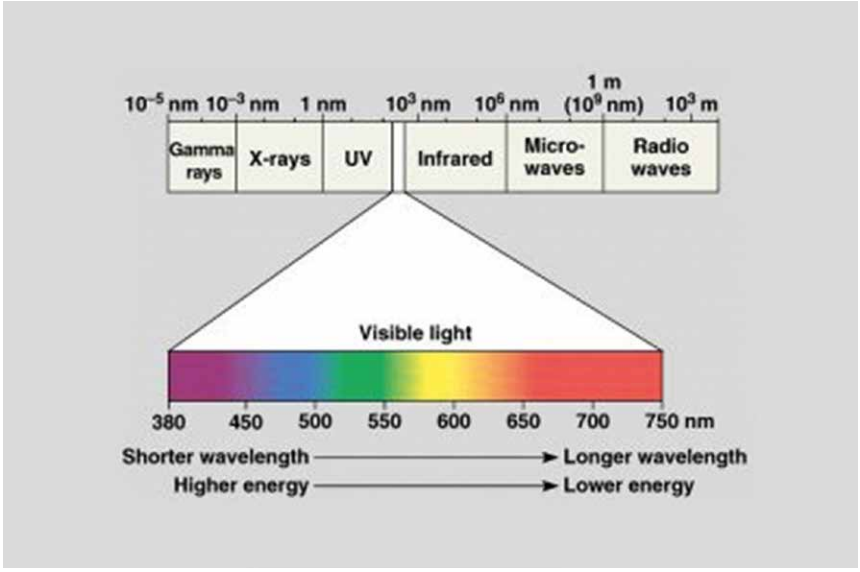


Figure 2: Photonics4All App Contents. Sources: pictures from Photonics4All App – Optics Valley

Promotion: A flyer promoting the App was designed, printed and disseminated and the App is currently promoted physically and electronically via the following means:

- *Social media* via the project's website, Twitter, Linked-in and Facebook.
- *Website* of Photonics4all (www.photonics4All.eu) and of all the project's partners
- Photonics4All *project events* such as Photonics Campaigns, Children's Universities, Conferences and workshops organized by the consortium's members and project's *newsletter (which can also be found on the Photonics4All website)*.
- *EYEST* via inclusion in the "Photonics Explorer" Photonics Education kit, which is widely distributed to teachers throughout Europe.

Impact: Formative and summative evaluation took place as part of the development of the App and Opticsvalley responded to feedback in order to make improvements to both the operating experience and content. The quantitative impact is measured by the number of App downloads. After 6 months the App has been downloaded more than 300 times.

Costs: The total cost to develop the Photonics4all App was almost 10,000 €.

Gained experience and recommendations: Opticsvalley learned valuable skills and lessons in creating the Photonics App which included working with new partners and gaining new technical skills. Opticsvalley gained experience in communicating with young people and technical expertise in co-ordinating the development of an App.

The App was developed by students from a French School of Engineers and Optics and while the content and design is of a high quality and we were happy with the result, we regret not having planned for a larger budget during the original project proposal. In hindsight having a larger budget would have allowed us to engage a professional photonics science communicator rather than students, which would have resulted in perhaps a shorter consultation or coordination burden for us, but the App would have cost more to produce. However it can be noted that the stu-

dents too would have learned valuable skills useful for the photonics industry as a result of taking part in the project which would be an unexpected benefit in terms of impact.

Another thing we would change if we had to develop a new App would be the format. The Photonics4all App was initially developed for Android, but it would have been more effective to develop it under a web version at the beginning, because our target group plays with Apps not only on their smartphones or tablets, but also on their computers and laptops. After completing the Smart Phone App version, in response to partner feedback we then had to organize and pay for the conversion of our Android App into a web version just a few months before the end of the project to get more visits.

Our recommendations include the following:

- Always have internal staff able to update the content of the App, even if the initial development was subcontracted (there are always updates to be made, and you will need to be able to do so rapidly)
- Test the App with the target group (children in this case), or at least with someone who is not an expert in your field (photonics in this case)
- Have a budget for getting support from social media specialists in order to market and disseminate the tool

Knowledge angel / point of contact:
Fiona Gerente, Opticsvalley

3 Photonics Games

Objective: *To use the creation of Photonics Games to introduce young people to the field of Optics and Photonics.* The use of educational games, in particular board games, can be an effective tool for *raising awareness and teaching scientific concepts and ideas such as photonics and light technologies.* Directly involving people in the process of creating original board games on photonics and light, proved to be even more effective. In Photonics4All, Games activity aimed to exploit the use of board games and the creating of board game for these purposes.

Target group: children (pupils aged 10–18 years)

Organisation: This section will cover first an overview of the Game project components, secondly, the development of the games, thirdly the manner in which the tool was promoted, fourthly the academic impact of the activity and lastly the promotion.

The Photonics games activity is based on three main complementary components;

1. the *use of board games* based on the science of light to raise awareness of Photonics and provide learning opportunities
2. a creative laboratory for the *design and making of original board games* based on light;
3. a *competition for high school students* for the creation of board games based on light and photonics.

The first two elements take place in schools and in public events – such as science festivals and games festivals, with a large, young and interested audience and a moderate organisation work load. The last component, the competition, requires, an accurate development and organisation to define the rules, select a winner and organise an official award ceremony.

Development: The following took place as part of the development of the games.

- Creation of a dedicated website (www.fotonicaingioco.it) and Facebook[3] page
- Definition and publication of the competition rules (www.fotonicaingioco.it/bando).
- Collaboration agreement with an important Italian board game agency (Studiogiochi) for a shared award ceremony in occasion of the "Premio Archimede"[4], the main Italian competition for board game designers.

In order to facilitate the planning, completion and promotion of the project the following tools were created or purchased, and used:

- a Flyer presenting the "Photonics Games" competition
- Quantum Race, an educational board game on Quantum Mechanics and wave-particle duality (5 table-top copies)
- Quantum Race, giant version for exhibitions (4.0 m x 2.5 m)

3 http://www.facebook.com/fotonicaingioco
4 http://www.studiogiochi.com/p/Archimede-Edizione-2016.html

- Roll-up presenting the "Photonics Games" competition
- Roll-up presenting Quantum Race game
- Awards: Each of the three best games was awarded by a prize of 600 Euros, devolved to the schools of origin with the obligation to be spent as contribution for didactical activities suggested and in favour of the winners' classes. These three best games were admitted to the final ceremony during the activities of Premio Archimede 2016 where the first, second and third places were announced and awarded with certificates and trophies.

Promotion: In order to promote the competition and project the following actions were taken;

- Announcement in newsletters specializing in science outreach, teaching and board games.
- Invitations e-mails were sent to Public Italian High Schools offices.
- Promotion at a number of different Science and Games Festivals around the country who hold labs / workshops and exhibitions, and who give talks to the general public.

Examples: Photographs of Games design workshops are shown below.

Figure 3: Giant version of the Quantum Race educational board game in use. Source: Institute for Photonics and Nanotechnology of the National Research Council

Figure 4: Playing session using the Quantum Race educational board game. Source: Institute for Photonics and Nanotechnology of the National Research Council

Figure 5: Participants of a games project at the final award ceremony. Source: Institute for Photonics and Nanotechnology of the National Research Council

Impact: The Impact of the Games Project was measured both quantitatively, in terms of the numbers of students who directly took part in the activity as well as the number of game projects that were launched, and qualitatively through evaluating feedback from teachers and students. The impact of our game competition activities in photonics4All can be summarized as follows:

- Number of participating students (426).
- Number of submitted games (28).
- Total people involved in the different activities (about 1,500).
- Feedback from involved teachers (excellent).

Academic activities: The competition was accompanied by academic activity which aimed to assess the effectiveness of the tools that were used, particularly to determine best practice. This academic activity included participation in conferences and publication in journals as outlined below:

- F. Chiarello, Board Games to Learn Complex Scientific Concepts and the" Photonics Games" Competition, Proceedings of the European Conference on

Games Based Learning, Academic Conferences International Limited, p. 774 (2015)

- F. Chiarello, M. G. Castellano, Board Games and Board Game Design as Learning Tools for Complex Scientific Concepts: Some Experiences, International Journal of Game-Based Learning (IJGBL), Vol. 1, p. 6 (2016)
- F. Chiarello, Games Design as Learning Tool for Science: the Photonics Games Competition Experience, Proceedings of the European Conference on Games Based Learning, Academic Conferences International Limited, p. 123 (2016)

Costs: The competition to develop a photonics game throughout Italy was implemented with about 10,000 € and immense efforts & commitment from the partner organisation in charge of it.

Experience and Recommendations: The use of games and games creation proved to be an effective tool for awareness raising and for teaching those involved about Photonics; particularly young people and students, but also for adults, teachers and the general public.

It was particularly helpful to participate in existing events such as science festivals and games festivals in order to reach a large young and interested audience.

Moreover, the experience allowed the construction of a network of contacts between different parties such as researchers, teachers, event organizers, journalists, games experts etc., a network that will foster the games activity in the future, well beyond the end of the project.

A particular emphasis must be placed on considering the different competences required in this activity and the necessity of professional support (scientific, teacher, games specialists etc.), which can be easily found right in the developed network of contacts, which ensure that the work is not addressed from just a single point of view. Regional differences must be considered and, in this case, they were a valid strength and support.

Our *Recommendations* include:

- Make direct contact with teachers and schools
- Consider regional differences
- Use existing events such as science festivals, games festivals, competitions.
- Do not underestimate the large amount of time required for the organisation, contacts, evaluation of participating games etc.
- Give maximum visibility and recognition to students and participating schools.
- Pay particular attention to balancing scientific contents and fun.
- Use the promotional activities to build a network of people with different expertise (game design, science, outreach, teaching, event organisers etc.) and use their experience and suggestions.

Knowledge angels / point of contact:
Fabio Chiarello, Maria Bondani, Institute for Photonics and Nanotechnologies of the National Research Council

4 Photonics Animated Video

https://www.youtube.com/watch?v=xm8njcBrXY8

Objective: To create a short cartoon for children, introducing them to photonics and its use in our daily lives.

Target group: It was designed to address very young children who have just begun to understanding scientific and every day phenomena (e. g. rainbows). However the final animation video appeals to people of all age groups.,

Development: This section covers the planning, creation and promotion of the animated video.

The main steps for the development of the video were:

- Writing the script
- Defining the appearance of the main characters
- Check the content to make it as much as possible suitable for very young children

The most important element of the planning was the creation of the video's main character, Max. The Photonics4All partners were keen to encourage more girls into science, so a female character was chosen to promote the role of women in Science Technology, Engineering and Maths (STEM). The partners were all keen to make sure Max appeared to be an assertive and popular character, and didn't appear to be a 'nerd' or have any factors that are stereotypically linked to science people in animation movies (for instance wearing big glasses).

The video 'The stolen cup' introduces the video's narrative. The story was conceived to be easily understandable around the world. Although, the elements that Max is using are described in English, these tools are usually understandable in all languages and are combined with images which are placed next to the description. In addition, the description of the video in YouTube was translated into eight European languages (English, German, Spanish, Italian, Slovak, Swedish, Dutch and French).

The technical and graphical development of the video was sub-contracted to a professional animation studio.

Here are a few screen shots of the video with German subtitles depicting photonics applications:

Figure 6: Screen shots of the Photonics4All animated video "The stolen Cup". Source: Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH

The final video can be watched on the following link:
https://www.youtube.com/watch?v=xm8njcBrXY8

Dissemination and promotion: The award-winning video will continue to be used and promoted by Partners long after the end of the project. The video was promoted through a number of different channels listed below.

- *Social media* via the YouTube channel of Photonics4All, Twitter, and Max's profile on Facebook as well as the Facebook account of the project
- website[5] of Photonics4all and of all the project's partners as well as project newsletters
- *project events* like campaigns, children universities conferences and workshops organized by the consortium's members.
- *other web platforms:* In particular the video won the first place of the video science contest of the International Year of Light 2015 and is promoted as such on the website of the IYL2015[6]. The video was also advertised in the Photonics21 newsletter.
- *local cinemas* to diffuse the cartoon as preview before the main film

Impact: Determining the quantitative impact of the video has to date included counting the number of views on YouTube, but such a counting does not take into account that several Photonics4All partner used the video to show to large audi-

5 http://photonics4all.eu/young-people/photonics-video/
6 http://www.light2015.org/Home/About/Resources/Videos/Photonics4All---The-Stolen-Cup.htm

ences at events for instance. For example one 'view' can hence result in over 300+ audience members watching the video. The video was shown in one cinema before the main film four months long. It is therefore difficult to exactly track the number of views of the video. The number of 'Likes' and account members have also been gathered on social media. In terms of qualitative impact evaluation was done formatively during the design phase, with Photonics partners and young children giving feedback and advice that was adhered to. Summative evaluation methods have been more informal; observations were made by partners watching audience's responses to the video for example the video was shown as part of the Children's universities in Germany and the youngest children were particularly attracted by the video.

Costs: The video produced was of very high quality because of the involvement of a professional animation studio, however this meant that the costs of production were high: about 10,000 € for a 93 seconds film

Experience and recommendations: It was a real challenge to develop a cartoon on photonics with no spoken words in the video enabling the video to appeal in countries across Europe. We recommend to start early with the writing of the script. The writers need to put themselves in the position of a young child and it is advisable to ask children explicitly about their opinion on the video as well. In addition, we particularly recommend having a strong social media strategy for the dissemination of the video to ensure sufficient promotion for such a professional video. The video was shown at many of our events but it proved difficult to have it shown for instance at local cinemas before the main film. One needs to have either a good proven network of cinemas for it or / and some budget dedicated to such a dissemination channel which is not for free. In our case AIDO had such a network with but we lost the contact to this network of cinemas when AIDO went bankruptcy.

Knowledge angel / point of contact:
Aude Pélisson-Schecker, Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH

5 Photonics Children's Universities

Figure 7: Children's University at the University of Southampton. Source: pictures by University of Southampton

Definition: In general, 'Children's Universities' are understood as *events offering workshops and lectures for children during their holidays.* The workshops and lectures include experiments, competition activities and educational games. In some situations Children's Universities may not exist, so bespoke voluntary events can be organised for children during school term-time.

Objective: The aim of the Children's Universities was to try to *familiarize school children, teenagers and their parents (and some teachers) with the term 'Photonics' and of the importance of Photonics in our lives.* School children were encouraged to

engage with photonics to build on their existing knowledge of science and technology. The objectives of the Children's University included acting to:

- improve their understanding of light and photonics
- raise their interest in STEM subjects
- fascinate them with the world of light – both in the present and the future
- encourage them to study Physics at university
- make them researchers and / or entrepreneurs in photonics

Target group: children / young people (7–15 years-old)

Organisation: The project consortium conducted nine children's universities in five countries during the two years. The University of Southampton, Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH, Photonics Sweden and Photonics Austria promoted photonics using all the developed tools of the Photonics4all project (app, video, game etc.) and utilized the Photonics Explorer Kit of Eyest$_{vzw}$. The partners in Germany, Austria and Sweden took part in existing regional 'Children's Universities' and the UK instigated its own event. All the activities increased our youngest "researchers' awareness of photonics.

Learning Objectives: Our informal educational approach meant that we were not required to assess individual student's learning formally during this project, however we wanted participants to be able to define 'Photonics', learn some basic light theory know some applications of photonics and obtain some practical skills. Sample learning objectives are shown below:

Participants are to know about, or understand the following:

Sources of light:

- The sun as most important light source
- The light bulb and other artificial lighting
- Lasers

Basic Light Theory included the following:

- The speed of light
- Light is propagating as a wave,
- Different colours correspond to different wavelengths
- Colour perception of the human eye,
- Additive and subtractive colour mixing and filters
- Structural colour in nature and nanotechnology
- Light and shadow: creation of coloured shadows and discussion of light pollution
- Why the sky is blue: absorption and scattering of light

Measurement of and with light:

- Explanation of the unit nanometer
- Diffraction gratings and spectroscopy
- Optical spectra of different light bulbs: incandescent, energy-saving and LED lamps
- Optical instruments: reading-glass, telescope and microscope
- Usage of a research-grade microscope: study of crystals, flies and computer chips

Applications included:

- Light can transport information and telecommunication
- Manufacturing with lasers
- Lasers and medicine
- Photonics, art and entertainment.
- Inkjet printing

Event Structures: The Children's Universities events included talks, workshops, booths and hands-on activities. Talks for the children were highly interactive and entertaining. Some talks involved a professional laser light show and included the distribution of diffraction gratings to the children to allow for mass experiments during the lecture. Some lectures included information on the use of photonics for art and entertainment, as well as biophotonics, telecommunications and manufacturing.

Some Children's University events took place in a lecture rooms or theatres allowing 100–150 children to participate. Many universities also offered the technical possibilities for video transmissions in the next room, to allow parents, waiting for the children, to follow the lectures too. Some events then included splitting the children into smaller groups to allow for hands-on optics and photonics demonstrations. Groups were rotated allowing them to take part in up to four activities throughout the day. The visits were free and at most events the children were fed a small snack. In existing Children's Universities the children had to register for each upcoming lecture a week before the event started at the university homepage. In the UK, where there was no existing Children's University structure, schools asked for young people to volunteers to attend two months in advance of the event. Some universities allowed schools to register whole classes as it was the case for an optical data transmission lecture that will be described in this handbook. There was very often a waiting list for the children who were too late for the registration.

Workshops and booths: another option for promoting photonics is to include workshops and a booth or stand during larger Children's University, community or science promotion event where it is not possible to provide special lectures on photonics. During these workshops and at the booth, it is possible to conduct various experiments and hands-on activities with the children. For examples – see Annex 3 Example of experiment used in the Children's University (spectrometer).

Staffing the activities: The lecturers of the Children University are normally teaching staff at the respective University but they can also come from other institutions. Lecturers prepared a lot of material for the children to work with during the event and to take home too. Those working on the events also included undergraduate students, postgraduate students and University academics. It is extremely beneficial for industry partners, as well as University staff and students, to help run events

too; that way children are shown a clear path to a career in Photonics and how studying photonics can benefit them. It is also beneficial for all lecturers to go through some sort of basic training in how to work with young people. (Otherwise it is easy to use vocabulary and concepts that children, of certain age-groups, find too hard to understand). In the UK it was also important that the people who supervised the work with children had gone through a bureaucratic process to ensure that they are suitable adults to work with children and can ensure their safety (DBS Checks).

Content: Partners prepared many practical activities and experiments to explain different aspects of light-based technologies & photonics, combining the hands-on teaching with having fun while learning about the basic optics concepts. (Please see sample activity shown in Annex 3). We engaged the interest of not only the children but also their parents (by including them in the lectures and providing their children with activities to take home) and we gained very positive feedback from evaluation feedback comments and questionnaires.

Many experiments and demonstrations performed during the events used EYEST-vzw's Photonics Explorer kit[7]. As the experiments in the kit are designed for long sessions, we picked out and combined parts of the documented experiments to fit into our various time scales. In addition, we added own experiments such as the *coloured shadows* in additive colour mixing of different light sources.

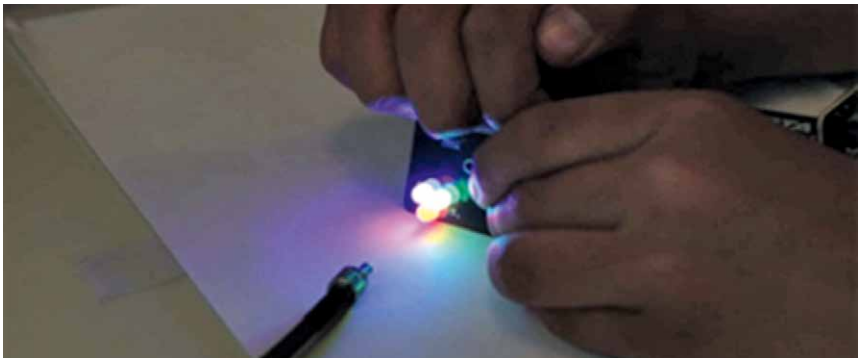


Figure 8: Element from the Photonics Explorer Kit. Source: picture by University of Southampton

7 http://www.eyest.eu/STEM-Programs/Photonics-Explorer

We also provided different types of light sources to explain the differences in the optical spectra and extended the content of the Photonics Explorer kit with a blue laser, to visualize the different scattering properties compared to the red laser. This was essential for the understanding of the blue coloured sky. Special emphasis was put on the usage of a research-grade optical microscope and the investigation of small things together with the pupils. A big LCD screen was connected to the microscope, such that all participants were able to see the magnified images of e. g., a computer chip, a small fly and a pure quartz crystal. Other partners included activities such as creating collages with polarizing filters and transparent tape, making animated 3D Pepper's Ghost images with smart phones, creating light art images with long exposure photographs and assembling LEDs and batteries to create edge-lit laser-etched name badges. (Some of these activities are illustrated in figure 7 above).

Photonics4All tools were used as well of course. Among them the photonics app[8] was promoted with flyers and used with touch screens – suitable for older children with smart phones, their parents and teachers. Different quizzes[9] were printed in the local language and offered for the interested, and were used to determine student's learning. Naturally, the photonics Children's video[10] was also displayed in screens at the Photoncis4All booth at a Children's university event when appropriate for the age-group of the students attending. The bookmarks[11] proved very popular for students aged 14+ years.

The same kind of approach used for Children's Universities can be applied also to Summer Schools. We have used the Photonics Explorer kit during the International Physics Summer School – Optics held in Como (Italy) and Olomouc (Czech Republic) to enable students to build some of the experiments. The advantage of the kit is to offer enough optical components to replicate the experiments.

Impact: We aspired to measure both the quantitative and qualitative impact of our Children's Universities. The quantitative Key Performance Indicator was to reach 100 children during each children university / activity. In addition, a qualitative

8 https://play.google.com/store/apps/details?id=esiee.android.nevyan.photonicsforall&hl=de
9 http://photonics4all.eu/young-people/photonics-quiz/
10 https://www.youtube.com/watch?v=xm8njcBrXY8
11 http://photonics4all.eu/general-public/photonics-bookmarks/

evaluation scheme was found necessary to understand the success of the activity in terms of delivering objectives. We used something similar to the template evaluation below.

Event facts				Quantitative evaluation			Qualitative evaluation	
Date	Partner	Event	Age-group	Number of participants	Number of Girls	Amount of Photonics4All budget used (no personnel)	Change in knowledge What have you learned? (Feedback boards, post-it notes, social media ...)	Change in attitude – are the students more interested / inspired about Photonics? (Feedback boards, post-it notes, social media ...)

Figure 9: Example of evaluation template for Children's Universities. Source: children's university – University of Southampton

Methods of data collection included paper questionnaires, online evaluation forms and boards for young people to write on as shown in the photographs below.

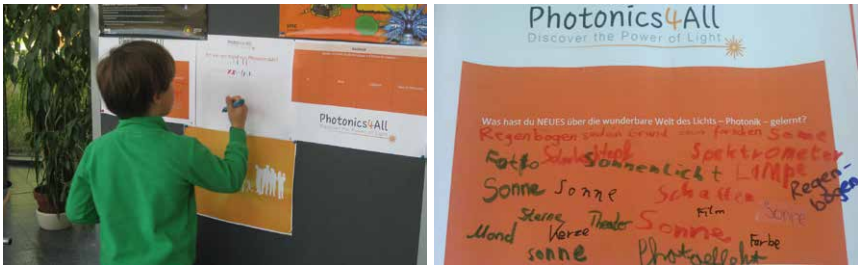


Figure 10: Methods of data collection used for evaluation. Source: KIT children's university – Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH

Evaluation material was summarised by some partners using infographics shown on Figure 11 below.

During the project we reached over 3,800 young people at different events, far in excess of what was planned, because the project benefitted from the many opportunities for outreach that the International Year of Light afforded. In terms of long-term evaluation one project partner, the University of Southampton, was able to use a tracking system which enables the University to determine whether

individual students who have taken part in particular Outreach events have signed up to study Physics as a result.

Costs: The costs of the activities varied between 400–4,000 Euros depending on the activities of the respective Photonics4All partner and the design of the event. Some partners organized an entire Children's University for several days without any other sources of funding, others organized workshops with the financial and or organisational help of other projects or organisations and others had the material they needed already available.

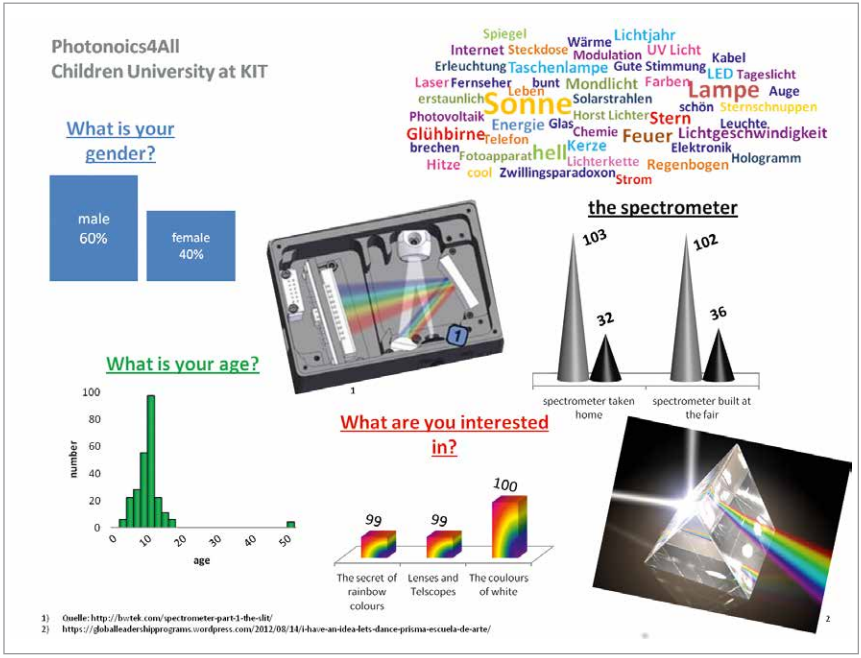


Figure 11: Infographics illustrating the evaluation of a Children's University conducted at the Karlsruhe Institute of Technology, Germany.
Source: Steinbeis-Europa-Zentrum, Steinbeis 2i GmbH

Gained Experience and Recommendations: The following is recommended:

- Planning events should include an element of evaluation – a sample plan can be found here[12] in the form of logic plan (see also Annexes 1 & 2). Have clear, measurable objectives.
- If long-term impact can be evaluated – do plan for it in the case of Universities who wish to determine the impact of their outreach activities.
- Ensure a gender mix of participants.
- Ensure that all those delivering activities and events have received appropriate public engagement or outreach training.
- Add an element of Photonics to existing Science, Technology, Engineering, and Mathematics (STEM) activities and where possible include students, researchers and industry members so that participants gain a clear idea of where their interests could take them in terms of their career.
- Include an element of creativity with a STEAM (the "A" standing here for "Art"), rather than STEM to make the activity cross-curricular and encourage greater participation.
- Enjoy! Ensuring that participants and demonstrators are having fun impacts learning and makes events more memorable.

Knowledge angel / point of contact:
Pearl John, University of Southampton

12 http://www.ahrc.ac.uk/documents/guides/logic-models-for-programme-planning-and-evaluation/

6 Photonics Teacher Training Sessions

Objective: to offer a one-day workshop / training for teachers to *increase their awareness of the potential use of photonics during physics lessons to inspire* their students. The workshop / training tools below (see 'tools') can be used for collaboration with further education facilities.

Target group: Teachers at all education levels. Teachers are multipliers and can influence what students focus on later in their working lives. Experience has shown that children from preschool up to higher secondary education can profit well from experimental learning.

Organisation: This section outlines the venues training occurred in, the tools and equipment used in the workshops, content of the workshops and online support in teaching the workshops.

The workshop / training sessions were held at *teacher's further educational facilities.* This formal approach was to ensure the sustainability of this activity for the future. Ensuring that workshops are given in conjunction with formal teacher training facilities gave them a visibility and prestige. The main focus of the training sessions was to distribute "The Photonics Explorer Kits" to teachers who are in this occasion fully trained to use them.

Tools: The *Photonics Explorer Kit* of EYESTvzw: The kit equips teachers with class set of experimental material provided within a supporting teaching framework. Kits are provided free to schools if the kits are sponsored by industry, government and educational authorities, organisations or foundations.

The Photonics Explorer has been developed by an international team of teachers from 11 EU countries to fit into diverse educational systems and teacher cultures, as part of a European-funded project. The project was initiated by the Brussels Photonics Team (B-PHOT) at the Vrije Universiteit Brussel and brought together European industry, scientists at universities, teachers in secondary schools and several students.

The kit has been extensively tested with nearly 2,000 students in 7 EU countries and the didactic content is currently available in 13 EU languages; Bulgarian, Czech, Dutch, English, French, Finnish, German, Greek, Italian, Polish, Portuguese, Russian and Spanish.

The kit is distributed through EYESTvzw. One Photonics4All partner was already and three partners became new Local Associated Partners with EYESTvzw. They are now responsible for teacher training and distribution of the Photonics Explorer kits in their country.

Other *Photonics4All tools* used in the teacher training workshops included:

- the 'Photonics App'
- Photonics Video
- Photonics Games
- Photonics Bookmarks

Content: Typical training topics covered in the workshop include:

- Total Internal Reflection
- Lenses

- Telescopes
- Polarisation
- Diffraction
- Encouraging Girls and young Women into STEM and Careers in Photonics

Video Training Tutorials regarding the suggested topics were developed. They can be found online at the Photonics4All YouTube channel and are very helpful to establish a training program:
https://www.youtube.com/channel/UCc0a7cn5wOGn3kIks6X0-Gw

Figure 12: Distribution of kits to the IOP Capital Physics Project's Teaching and Learning Coaches in UK. Source: University of Southampton

Gained Experience and recommendations: Using the Photonics Explorer Kit for teacher training workshops is highly recommended as the kit provides all the necessary equipment for up to 10 parallel experiments in a class. The kit also includes suggestions for lesson preparation and worksheets which can be adapted by individual teachers to suit their own needs. In order to prepare an experiment the suggested video tutorials have shown to be very helpful. Organizing teacher

training through teacher's further educational facilities have proven to be a very good way to approach motivated teachers and secure a system that conforms to established teacher training provision.

Impact: Within Photonics4all project, about 35 workshop / training sessions in 4 countries were organized and delivered, training more than 2,200 teachers.

Some months after the workshop, the respective partners sent around a questionnaire to the participating teachers to gather the following qualitative data, which showed a high satisfaction of teachers, an increasing students' interest in photonics. The following quotes from teachers were collected in UK:

"A fantastic resource."

"Not just a box of kit, but a classroom-ready set of resources."

"Excellent for "girls in physics" events and after-school club activities."

"Solves the "never enough ray boxes" problem at a stroke".

Costs: one Photonics Explorer kit (150 Euros, excl. VAT) was given to each participant school. Room hire and travel costs and catering for events may also be necessary.

Gained Experience and recommendations: Using the Photonics Explorer Kit for teacher trainings is highly recommended as the kit provides all the necessary equipment for up to 10 parallel experiments in a class. It also includes suggestions for lesson preparations. In order to prepare an experiment the suggested video tutorials have shown to be very helpful. Organizing a teacher training through teacher's further educational facilities has proven to be a very good way to approach motivated teachers and secure a system conform teacher training.

Knowledge angel / point of contact:
Ulrich Trog, PhotonicsAustria

7 Other Photonics activities for young people

Workshop organized at specific location (Science Centre)

Objectives: as for the Children's Universities, Objective, the aim was to try to *familiarize school children, teenagers and their parents (and some teachers) with the term 'Photonics' and of the importance of Photonics in our lives.*

Target group: young people / students and their parents

Organisation: If you have the chance to have a Science Centre in your city or a museum dedicated to science, you can also propose to them the possibility to install a (semi-) permanent exhibition regarding light. This installation can form the basis of a workshop for classes who are visiting the museum. The Delft University of Technology works in connection with such Science Centre and the Optics group was able to build a discovery room based on light inside it.

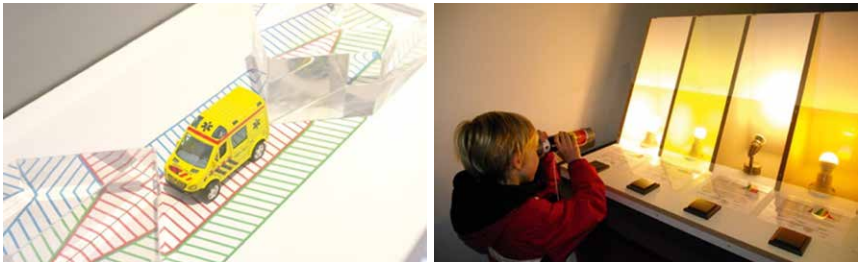


Figure 13: Hands-on experiments in the Science Centre of the Delft University of Technology. Sources: University of Delft

The great advantage of working with a science centre display is that the exhibition lasts longer, is seen by more young people / students and also involves their parents if the place is open to them. You also profit from the experience of the people working there to have durable and attractive set-ups for the demonstration. As the museum provides you with a "free" space, and takes care of the promotion for you, this is very cost-effective.

If the venue organizes workshops for the schools or the pupils as they do in the Science Centre, this is a good option to have running alongside the exhibition and the workshops you plan can be connected to the display topic. The young people discover the exhibition and can later built, play, interact further with the topics covered, in the workshop.

Impact: The experiments were on display for four months from October 2015 to January 2016, with an average number of 2,500 children visiting the centre per month, reaching approximately 10,000 children during the exhibit. Usually these places have a good count of the groups visiting the museum. It is more difficult to estimate how many will stop to your designed room unless you evaluate audience response through observation methods such as asking visitors to take photos or videos of the activity, then interview them afterwards to find out what they looked at and engage with thoroughly. For the workshops it is easier to evaluate the satisfaction of the pupils with the help of the teachers that work with the students. (Although the teachers can tend to just react positively to anything provided for them unless specific questions are asked).

Time and Costs: in the case of the Delft University of Technology, a set for 5 experiments was built in a room. It took 2 months with 3 people (average 1 day a week) to design the different experiments with a budget of less than 2,000 €.

Experience gained and recommendations: If you plan such collaboration with a museum or a science centre, begin well (months) in advance, because these places (museums / science centres) have usually a well-planned schedule, quickly filled – possibly ten months in advance. However, if you approach a venue with inspiring, detailed plans and the ways and means (and budget) to build it, they may open their location to you even for a limited time.

Also in our case it was important to buy several of same parts in order to replace the broken ones. Moreover the exhibition has to be checked every week for realignment, fixing and other troubles that happen when young people / parents touched the experiments.

Knowledge angel / point of contact:
Aurèle Adam, TU Delft

LIGHTtalks: Careers in Photonics

This is an ECOP activity created within the GoPhoton! Project that has been exported to other projects such as LIGHT2015, and to a lesser extent to Photonics4All as well.

Objective: to *highlight* the following *aspects of photonics:*

- the importance of photonics as a career option for people from all different backgrounds,
- its great potential,
- and the many different disciplines which use photonics.

The goal of the talks is to *create awareness among students of the potential of Photonics* thereby encouraging them to consider Photonics as a career choice.

Target group: young people, university students and high school students

Organisation: LIGHTtalks consist of an array of live presenters from the scientific, entrepreneurial and industry communities speaking about different aspects

of photonics. The specific feature of the LIGHTtalks series is that through the profiles that are made available, talks are delivered using a predefined format and with guidelines and advice provided to local organizers to simplify the setting up and implementation of the events. While the profiles (see Annex 4) predefine the structure and topic of the LIGHTtalks, organisers are responsible for:

- identifying the venue and the speakers
- promoting and disseminating the activity
- implementing the activity

These profiles set the framework of the activity and ensure easy replication, at the same time allowing the organisers to adapt the activity to suit the local situation which takes into consideration the local research and industry landscape. This helps organisers identify suitable speakers.

Tools: As part of the LIGHT2015 project ECOP has developed the video "Careers in Photonics"[13], aimed at providing a glimpse into the professional opportunities that photonics offers. A briefing documentation to replicate LIGHTtalks activities can be found here[14].

Impact Measurement: Organizers were asked to provide the number of different stakeholders contacted for the event, and how many of those were engaged.

Satisfaction level of attendants was measured at different levels:

1. General level about the liking of the activity, structure, length and speakers. Some organizers went into further detail by segregating the event into phases and asking for the opinion about each individual speaker, for instance
2. Attendants were asked if the LIGHTtalk had been helpful to better understand and consider a broader range of career choices
3. The type of information provided during the event was also evaluated in terms of its usefulness.

13 https://www.youtube.com/watch?list=PLxdncwf4h751CxEc-o1xKKHLrHe63bgCL&v=RA5VnCFbnjM
14 http://www.europe.light2015.org/Home/Resources/LIGHTtalks.html

In addition, statistical information was collected, including attendance, female / male ratio, etc.

Costs: three main types of costs are associated to this activity:

1. Speaker costs (fees and travel)
2. Facilities
3. Dissemination materials

the total budget was between 500 and 5,000 euros depending on the organizer.

Knowledge angel / point of contact:
Lydia Sanmarti, ECOP Secretariat: ICFO – The Institute of Photonic Sciences

8 Conclusion and recommendations

Conclusion

All the above described activities were conducted successfully during the project, delivering on their objectives to address young people, their teachers and parents. Many different strategies were implemented to approach young people using different and new methods (such as the Photonics App and Video) or exploiting their different creative and scientific skills (in the case of the Photonics Games and during Children's Universities) and finally, by supporting the teaching of Photonics via Teacher Training workshops.

The following table summarizes very briefly the advantages & disadvantages of organizing different activities for young people illustrates (a much more detailed overview is available in Annex 5):

	Advantages	Disadvantages	Cost €	Results
Photonics App	High quality, practical outcome (the App) will be relevant and useful for a long time. Development of a new skill in the cluster which carried out that activity.	Very time consuming and high cost involved in reaching professional quality standard. Needs a lot of coordination with other partners and proof-reading to ensure accurate content.	10,000	Photonics4All App available on Google Play Store for Android and online: www.photonics4all-app.eu.
Photonics Games	Strong engagement with schools (students and teachers). Cross-disciplinary approach allows for gaining of both creative and scientific skills.	Strong commitment required by all those involved, a lot of time required for promotion of the activity.	10,000	28 submitted games, 426 participating students from 16 cities, 1 award ceremony in a national game competition event (national visibility)

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	Advantages	Disadvantages	Cost €	Results
Photonics Animated Video	Very easy access format very well favoured by children.	High costs to reach a professional quality.	10,000	90 seconds animated video "the stolen cup" distributed on social media and published on different web platform
Photonics booth at an existing Children's University, Photonics talks at STEM events	▪ photonics booth or input in a pre-existing outreach event enables access to large audiences with minimum organisation efforts ▪ easy to implement using existing experiments e. g. proposed in the Photonics Explorer Kit from EYESTvzw ▪ direct contact with children & teenagers	▪ need to be well prepared / trained so that experiments work well at once ▪ very much going on at the same time, so that it is difficult to manage the collection of feedback questionnaires ▪ large number of children spending a limited amount of time at the booth limits the impact	about 400 (for 2 photonics explorer kits + some additional consumables)	Over 3,000 children reached in over 20 children's university or STEM events, offering participants about 10 different experiments
New Photonics Children's University (conception from scratch)	▪ delivering a day-long set of photonics outreach events enable visiting young people to focus their attention on photonics activities ▪ Sufficient funding allocated to allow the development of exciting new outreach activities which were piloted and evaluated. Funding allowed a high demonstrator / pupil ratio allowing pupils a good amount of interaction	Time consuming to prepare and very expensive to deliver	4,000 per event	120 young people reached, 20 post-graduate students trained to deliver 5 new hands-on activities for young people. Photonics Explorer kit utilized.

»

	Advantages	Disadvantages	Cost €	Results
Photonics Teacher Training Sessions	▪ Working with EYEST's ‚the Photonics Explorer' kit provided Photonics4All partners with an excellent existing tool to use and disseminate. ▪ Each participant teacher will reach more than 30 students per year ▪ The kits also provide partners with demonstration tools which they can use themselves long after the project has ended.	▪ Teaching teachers requires the workshop leader to be highly skilled in both Photonics and the kits themselves. ▪ The Photonics Explores kits have a cost, sometimes non negligible for the schools ▪ While partnering with EYEST in the future to distribute kits is extremely beneficial; fund-raising for the kits can be time-consuming and difficult depending on institution.	180 per distributed kit	▪ 535 participants in 31 regular-size training sessions ▪ 1,800 teachers in 4 big training outreach events ▪ 5 German + 12 Dutch video training tutorials (also available in English)
Photonics workshop at a science centre	Open to everyone joining the Science Centre	No one present in the room (unless a group is visiting) to help the children with the understanding	2,000	~2,500 children visiting the science centre per month
LIGHTtalks: Careers in Photonics activity.	Modern format interesting for young people	Need for high-quality lecturers	500–5,000 / event	150 participants at 2 events

Since the activities were very diverse, any agency willing to support the dissemination of Photonics towards young people can choose the most suitable one for them according to the age of the target group, the available resources (both financial and human) and the scale of the activity.

As a final recommendation we would like to stress the need of implementing some evaluation of the results before, during and at the end of any activity to optimize efforts and impact and to budget for this when planning.

What extra support could be provided by policy makers?

Optics and Photonics topics are only marginally included in the present curricula for primary and secondary schools. Nevertheless, the activities carried out during the project demonstrated that Photonics can be very effective in involving young people in science. This is very important since Photonics is perceived to be one of the key technologies of the 21st century by the European Commission.

We would advise policy makers at any level to support the introduction of *more Optics and Photonics contents in the schools,* both changing the institutional programs and supporting the training of and requalification of teachers, and financing supplementary activities such as children's universities.

Furthermore, we would recommend encouraging a *multi-disciplinary, cross-curricular approach* to some aspects of the curriculum which can boost students' interest and to ensure a gender balance in chosen disciplines, encouraging more girls to study Physics for example.

Last but not least, we consider that the *use of various media in school* is quite important and we would be pleased if our animated video or photonics app could help teachers in their daily task. Some schools prevent the use of Facebook or YouTube by their teachers who are unable to use our materials in class. The *development of such educational tools* should be further and stronger supported by policy makers.

9 Annexes

Annex 1: Planning for Impact tool: Outreach for Young People – Booth at Children's University event

Aims & Objectives: (To include Learning Objectives)	**INPUTS** What is required to achieve the aims & objectives e.g.: how much time/money resources are needed? What needs to be organised e.g. Venue / support.	**ACTIVITIES** What the project does with the resources; its processes, tools, events, activities and actions (i.e. what are you going to do?)
To provide an enjoyable opportunity for students to visit a University or Company. To teach school children about Photonics theory & applications, inspiring them to want to study further. To encourage organisers to ensure both male and female students attend and are from a wide-range of backgrounds To provide hands-on activities to increase student's interest in Photonics To increase awareness of current research activities and careers with photonics amongst both students & their parents. To provide training opportunities for postgraduates or Industry employees to engage with the public and improve their communication skills	Funding/Time for: - Demonstrators/helpers time to include preparation & delivery eg. designing and piloting activities - Staff training - Equipment & Materials costs for activities - Promotional support of event through Social Media - Hire of Professional photographer for marketing purposes. - (Permissions of those photographed to be used in marketing publications) - Evaluation costs – preparation, printing, delivery and report. - Preparation of Student packs/giveaways eg. Bookmarks, Educational handouts.	The organiser will: - Help promote event - Design activities and worksheets - Pilot the activities with appropriate age-group - Evaluate the event (their own performance and the experience of the participants) - Assess event and activity for safety risks. - Deliver a One day event for visiting students consisting of the following: - A stand at an existing Children's University event supplying information on basic Light Theory, and Photonics Applications.

OUTPUTS Direct products of the project e.g. types, levels & targets of what will be delivered. (What will the participant do/produce?)	**OUTCOMES** Changes in participant behaviour, knowledge, skills, attitudes and level of functioning. What will the participant have learned?	**IMPACT** The intended or unintended change in organisations, communities or systems as a result of the project
The visiting student will: Watch an introductory talk/lecture on photonics Watch the Photonics4All video for families. Take part in hands-on optics experiments (from the Photonics Explorer Kit) Make a hand-held spectroscope to identify gases, and take home. Complete a Photonics Quiz Complete an evaluation form, or write up evaluator comments to record what they learned, how much they enjoyed themselves.	To have an improved level of understanding of photonics: Light Theory and applications. E.g. To understand: Law of Reflection, Total Internal Reflection, Refraction, interference, diffraction, polarisation. To know and be able to list three applications of photonics. To have a more positive opinion of photonics research and researchers – or to sustain a positive opinion of research and researchers To have enjoyed themselves. To have an Improved level of knowledge with regard to life as a researcher or industry employee in Photonics. For student/employee demonstrators to have better communication and organisational skills.	For visiting students to study physics/ photonics at GCSE/A Level and in Higher Education. (Particularly female students and disadvantaged students) For parents and teachers to encourage students to study physics/photonics. For demonstrators to have an improved level of confidence in delivering outreach activities and public speaking and to have improved communication skills with non-scientists.

Annex 2: Planning for Impact tool: Photonics Outreach for Young People – Children's University Photonics Day Event

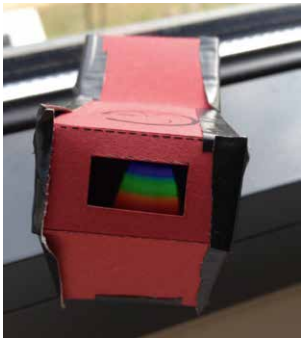
Aims & Objectives: (To include Learning Objectives)	**INPUTS** What is required to achieve the aims & objectives e.g: how much time/money resources are needed? What needs to be organised e.g. Venue / support.	**ACTIVITIES** What the project does with the resources; its processes, tools, events, activities and actions (i.e. what are you going to do?)
For students to visit a University and enjoy their experience. To teach 120 13-14 year-old students about Photonics theory & applications, inspiring them to want to study further. To ensure both male and female students attend and are from a wide-range of backgrounds To provide hands-on activities to increase student's interest in Photonics To increase awareness of current research activities and the career of a researcher amongst both students & their parents. To provide training opportunities for postgraduates to engage with the public and improve their communication skills	Funding/Time for: - Demonstrators/helpers time to include preparation & delivery eg. designing and piloting activities - Staff training - Equipment & Materials costs for activities - Advertising event to Student participants (Admin support) - hire costs & booking (2 x Lecture theatres, reception area, Labs. Free + Admin support). - Catering Costs (morning and afternoon drinks provided + sandwich lunch) for participants and demonstrators. - Travel grant for underprivileged school children. - Marketing design of flyers and printing - Press release - Post Press Release - Professional photographer Room for long-exposure images and marketing. - Evaluation costs – preparation, printing, delivery and report. - Preparation of Student packs/giveaways eg. Bookmarks, Educational handouts. - Arrange Laser Cutter access	The organiser will: - Create a marketing campaign to promote event - Design activities and worksheets - Pilot the activities - Evaluate the event - Assess for safety risks. - Deliver a One day event for 120 students consisting of the following: - An Interactive Laser light show with diffraction grating freebies - A Collage with polarising filters (polarising filters, CD Cases, acetate Scissors, tape) - Manufactured Name Badges (Acrylic, LEDs, lithium batteries, lanyards) - A Guess the Gas activity (worksheets/spectroscopes) - Creating 'Mobile Ghosts',(acetate Scissors, tape, instruction sheets)

OUTPUTS Direct products of the project e.g. types, levels and targets of what will be delivered (What will the participant do/produce?)	**OUTCOMES** Specific Changes in participant behaviour, knowledge, skills, attitudes and level of functioning. What will the participant have learned?	**IMPACT** The intended or unintended change in organisations, communities or systems as a result of the project
The visiting student will: - Take part in an interactive laser show. - Complete a Photonics Vocabulary 'Bingo' card. - Complete a Photonics Quiz - Make a collage from polarizing filters and take it home - Assemble an LED Edge-lit acrylic personalised name-badge. - Contribute to group, long-exposure 'LightTag' creative photographs. - Take part in hands-on optics experiments. - Identify gasses using a spectrometer - Create a 'Mobile Ghost' A 'Pepper's Ghost' 3D image on their Smart phones and take it home - Complete an evaluation form.	To have an improved level of understanding of photonics: Light Theory and applications. E.g. Law of Reflection, To understand: Total Internal Reflection, Refraction, interference, diffraction, polarisation. To know and be able to list three applications of photonics. To have a more positive opinion of photonics research and researchers – or to sustain a positive opinion of research and researchers Audience participation – enjoyment. Improved level of knowledge with regard to life as a researcher. For student demonstrators to have better communication and organisational skills.	For visiting students to study physics/ photonics at GCSE/A Level and in Higher Education. (Particularly female students and disadvantaged students) For parents and teachers to encourage students to study physics/photonics. For demonstrators to have an improved level of confidence in delivering outreach activities and public speaking and to have improved communication skills with non-scientists.

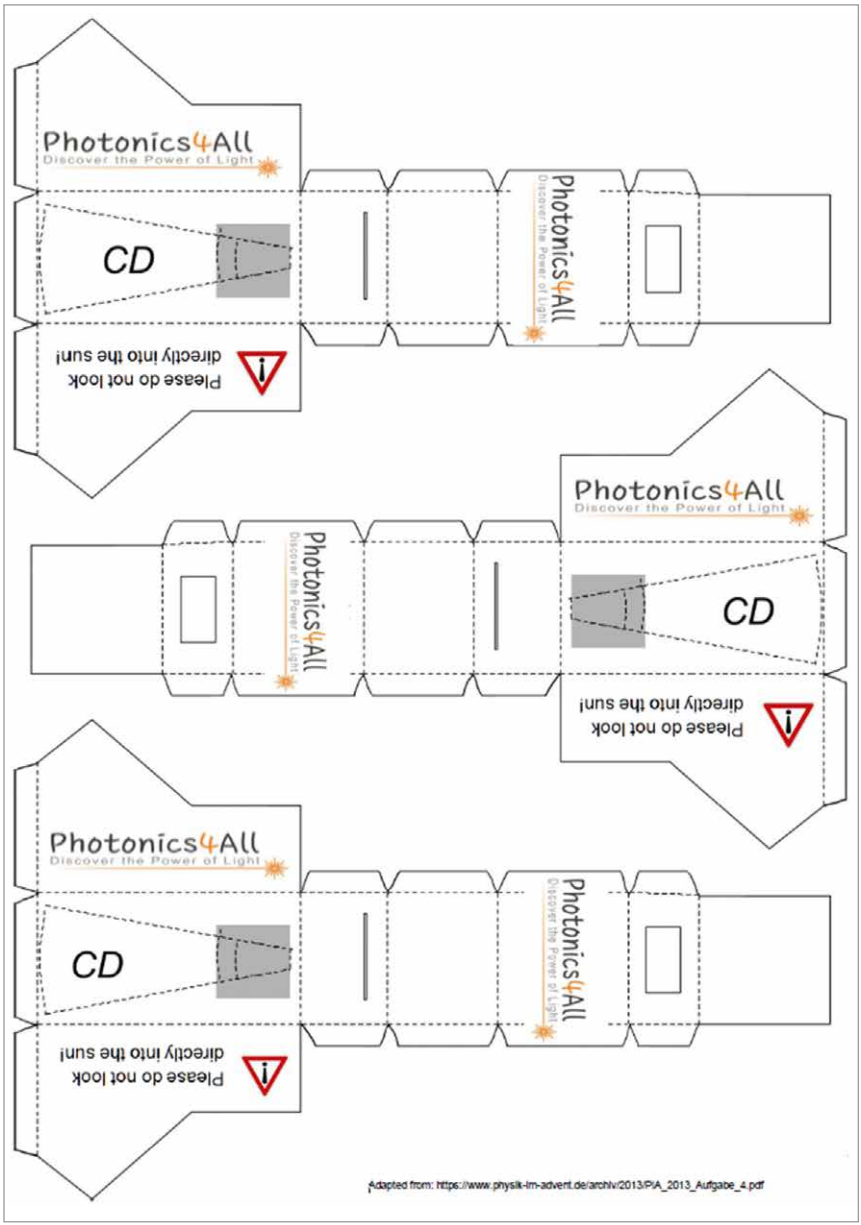
Annex 3: Children's University – "build your own spectrometer" handout

Spectrometers are an important tool for identifying elements in many scientific applications: build your own spectrometer!

Your spectrometer will use a CD-ROM to split up light into different colours. First, a slice of the CD must be cut out as shown in the plan on the following page (the best way is to use strong scissors or a saw!). *Please only use CDs which are no longer needed!* Print the page with the pattern overleaf on paper or card and cut the pattern along the lines. Cut the inner rectangles out carefully with a sharp knife. When you assemble the spectrometer, be aware that the piece of the CD should be inside the box. It is advisable to tape over the edges and corners with electrical or gaffa tape. Be careful not to tape over the rectangular areas!



http://www.physik-im-advent.de/archiv/2013/PiA_2013_Aufgabe_4.pdf


Photonics4All
Discover the Power of Light
CD
Please do not look directly into the sun!
Photonics4All
Discover the Power of Light
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Adapted from: https://www.physik-im-advent.de/archiv/2013/PIA_2013_Aufgabe_4.pdf

Annex 4: LIGHTtalks: Careers in Photonics profile by GoPhoton!

GoPhoton! ECOP European Centres for Outreach in Photonics

Description	A series of inspirational talks targeting university students focused on the potential of careers in photonics
	The session will contain a series of talks and interactive discussions with successful professionals representing different career options within photonics. The session will focus on: ▪ Expose students to the potential of careers in Photonics ▪ Reveal non-traditional career paths in Photonics ▪ Uncover the ubiquity of Photonics across disciplines
Objectives	To create awareness among the students about the potential of photonics thereby encouraging them to consider Photonics as a career choice.

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Structure	▪ *Introduction of the event* and the speakers by the moderator ▪ Screening of the ***careers video*** developed within LIGHT2015 ▪ *Introduction about photonics and the power of light* | 20 minutes ▪ *Inspirational talks* in pill format by each speaker (about 6–10 speakers) | ***5–10 minutes*** ▪ Short break ▪ Round table and Q&A session | 45 minutes
	Moderator: node's representative **Key note speaker:** *VIP profile:* to provide the general context of the impact of photonics in society, economy and people's well-being **Potential Speakers:** *Group of speakers representing different aspects of careers in photonics,* such as a professor, a CEO of a photonics start up, a Ph.D. working for a big company profile, a patent business professional, an outreach professional / journalist profile, somebody in the policy making arena, a tech transfer profile, or event alternative profiles such as an artist. Potential panel proposal: ▪ Academic research ▪ Big Company scientist ▪ Spin off creation ▪ IP specialist ▪ Outreach / journalism ▪ Networks, alliances and clusters ▪ Corporate Development ▪ Medical doctor ▪ Artists / professional in entertainment industry ▪ Architect Issues that could be addressed: ▪ Why is photonics interesting? ▪ How does photonics impact society through what I do? ▪ Potential of photonics for jobs ▪ Passion for photonics as a career path ▪ Economic impact of photonics ▪ Alternative careers

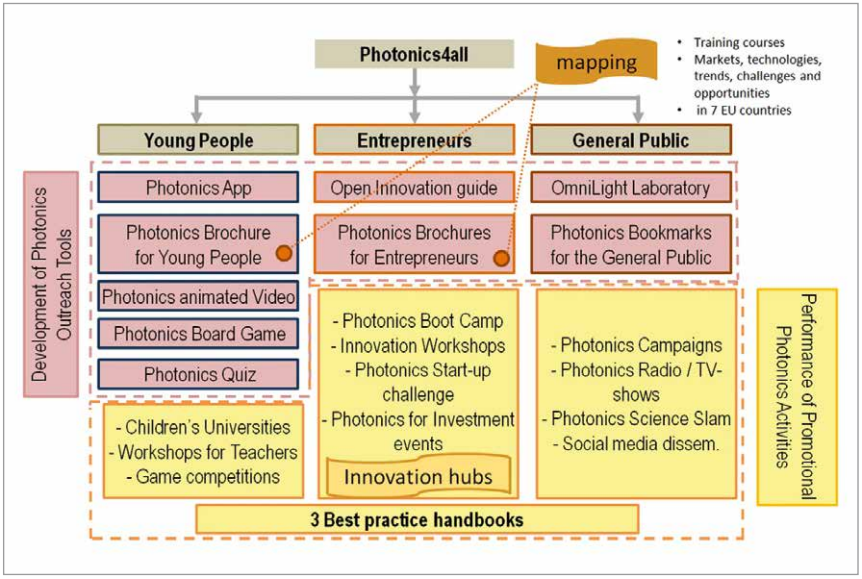
Annex 5: Overview and impact table for Photonics4All activities and tools targeted at the general public

Activity in Photonics4All	Target group = TARGET	Measurable aim = AIM	Required skills & infrastructure (things that one must have at hand and that not all organisations necessarily have = competence / material check) = BACKGROUND	Investment (quantification of Time, Money and involved Staff) = INVESTMENT			Estimated number of participants per event – e.g. for one workshop or one children's university = REACH	Estimated level of interaction with participants (low / medium / high) = ENGAGEMENT LEVEL (low = awareness raising, only little interaction with audience; medium = some interactions but only few individuals able to engage themselves; high = lots of interactions and most individuals able to engage themselves)	Estimated significance of the activity in term of change of knowledge and/or change of attitude, interest in photonics (low / medium / high) = SIGNIFICANCE	IMPACT (using low / medium / high scale) defined as REACH X SIGNIFICANCE	Gained experience in Photonics4All		Photonics4ll results
				invested time (in hours) per activity / event	estimated cost / event in Euros excluding personnel costs	number of staff involved					Advantages	Disadvantages	
Photonics App	Young people (15–20 years old)	- Familiarize young people with the term 'Photonics' and the importance of photonics in our lives - Make them discover this technology thanks to quizzes included in the App - Make them want to study science in order to specialize in Photonics later	Expert in Photonics and its applications + staff able to develop an App or supervise the delegation of such an activity (specifications, proofreading...)	800	10,000	0–5	over 1,000 downloads (Android + web version) within 12 months	low	N.A.	N.A.	High quality, practical outcome (the App) will be relevant and useful for a long time. Development of a new skill in the cluster which carried out that activity.	Very time consuming and high cost involved in reaching professional quality standard. Needs a lot of coordination with other partners and proof-reading to ensure accurate content.	Photonics4All App available on Google Play Store for Android and online: www.photonics4all-app.eu.
Photonics Board Game competition	children 10–18 year old	- organise a competition for board-game invention - use board games and their creation to raise awareness on photonics and light - test the effectiveness of games as a dissemination tool	- Being able to involve teachers and students in the development of the games and in the competition - communication skills"	420	10,000	0–3	400 participants to the competition	high	high	high	Strong engagement with schools (students and teachers). Cross-disciplinary approach allows for gaining of both creative and scientific skills.	Strong commitment required by all those involved, a lot of time required for promotion of the activity.	28 submitted games, 426 participating students from 16 cities, 1 award ceremony in a national game competition event (national visibility)
Photonics Quizz competition	Young people (18–22 years old)	- Familiarize young people with the term 'Photonics' and the importance of photonics in our lives - Let them discover the opportunities of a photonics when conceiving the Quiz	Being able to involve young people to join the competition – communication skills	70	600 (award for the competition winners)	0–5	2 students	high	medium	medium	Competition fun and easy to organize. Exiting to discover the quizzes elaborated in final for the competition.	Finding the competitors wanting to get involved in the competition	2 quizzes available online: www.photonics4all-app.eu and www.photonics4all.eu
Photonics Animated Video	young children < 5 years old	produce a small cartoon for children aiming at presenting photonics and how this technology is used today	the technical and graphical development of the video should be subcontracted to a professional animation studio	140	10,000	0–5	10,000–20,000 in one year (YouTube views + display at 20 events + 1 cinema before main film)	low	medium	low to medium	Very easy access format very well favoured by children.	High costs to reach a professional quality.	90 seconds animated video „the stolen cup" distributed on social media (https://www.youtube.com/watch?v=xm8njcBrXY8) and published on different web platform
Photonics booth at an existing Children's University, Photonics talks at STEM events	7–13 or 14–17 years old depending on the event	- familiarize school children & teenagers with the term 'Photonics' and the importance of Photonics in our lives - offer experiments and educational games about photonics - join an existing children's university	- 1 photonics Explorer kit from EYESTvzw - further small material (paper, scissors etc.) - simple good outreach and communication skills – having to explain complex concepts simply, changing explanations to suit the audience	40–70	about 400 (for 2 photonics explorer kits + some additional consumables)	2–3	150–200 children / day (event) or 10–20 pupils per workshop	high	medium to high	medium to high (for those who were actively involved)	- photonics booth or input in a pre-existing outreach event enables access to large audiences with minimum organisation efforts - easy to implement using existing experiments e.g. proposed in the Photonics Explorer Kit from EYESTvzw - direct contact with children & teenagers	- need to be well prepared / trained so that experiments work well at once - very much going on at the same time, so that it is difficult to manage the collection of feedback questionnaires - large number of children spending a limited amount of time at the booth limits the impact	Over 3,000 children reached in over 20 children's university or STEM events, offering participants about 10 different experiments

Activity in Photonics4All	Target group = TARGET	Measurable aim = AIM	Required skills & infrastructure (things that one must have at hand and that not all organisations necessarily have = competence / material check) = BACKGROUND	Investment (quantification of Time, Money and involved Staff) = INVESTMENT			Estimated number of participants per event – e.g. for one workshop or one children's university = REACH	Estimated level of interaction with participants (low / medium / high) = ENGAGEMENT LEVEL (low = awareness raising, only little interaction with audience; medium = some interactions but only few individuals able to engage themselves; high = lots of interactions and most individuals able to engage themselves)	Estimated significance of the activity in term of change of knowledge and/or change of attitude, interest in photonics (low / medium / high) = SIGNIFICANCE	IMPACT (using low / medium / high scale) defined as REACH X SIGNIFICANCE	Gained experience in Photonics4All		Photonics4ll results
				invested time (in hours) per activity / event	estimated cost / event in Euros excluding personnel costs	number of staff involved					Advantages	Disadvantages	
New Photonics Children's University (conception from scratch)	13–14 years old	To develop and deliver a day-long Photonics outreach event for young people. Students are: to increase their interest in Photonics and Physics and become more likely to want to study Physics in the future. (Long-term involvement to be measured through tracking individual students), be able to define Photonics and be able to identify at least three Photonics Applications and areas of research as a result of the event.	Suitable venue, trained student demonstrators, safety/risk assessment experience, established relationships with teachers marketing the event, administrative support to book rooms, catering parking etc. Marketing support to promote event. Professional photographer to document activities. Equipment readily available: Plasma lamps, fibre optic demonstration equipment, lasers, professional laser show, laser cutter, etc.	140	4,000 per event	20	120	high	high	high	- delivering a day-long set of photonics outreach events enable visiting young people to focus their attention on photonics activities - Sufficient funding allocated to allow the development of exciting new outreach activities which were piloted and evaluated. Funding allowed a high demonstrator/pupil ratio allowing pupils a good amount of interaction	Time consuming to prepare and very expensive to deliver	120 young people reached, 20 postgraduate students trained to deliver 5 new hands-on activities for young people. Photonics Explorer kit utilized.
Photonics Teacher Training Sessions	Teachers and, indirectly, 10–18 year old students	- Organise training sessions for teachers using the EYEST photonics Explorer kit, - reach a large number of students during classroom lectures	The experts responsible for the teachers training sessions need a deep knowledge of Optics and Photonics and of the material of the kit.	10–20 per training	180 per distributed kit	1–2	10–20 participant per training session on average	high	high	high	- Working with EYEST's ‚the Photonics Explorer' kit provided Photonics4All partners with an excellent existing tool to use and disseminate. - Each participant teacher will reach more than 30 students per year - The kits also provide partners with demonstration tools which they can use themselves long after the project has ended.	- Teaching teachers requires the workshop leader to be highly skilled in both Photonics – and the kits themselves. - The Photonics Explores kits have a cost(180 Euros/kit), sometimes non negligible for the schools - While partnering with EYEST in the future to distribute kits is extremely beneficial, fund-raising for the kits can be time-consuming and difficult depending on institution.	- 535 participants in 31 regular-size training sessions - 1800 teachers in 4 big training outreach events - 5 German + 12 Dutch video training tutorials (also available in English)
Photonics workshop at a science centre	7–15 years old + General Public	Put easy experiment in the hands of children and show they the wonder of photonics	A location open for this kind of exhibition. Helpers for building the experiments, which resist to time.	140 full time equivalent (3 months to develop but not fulltime)	2,000	3	Usually group of 15 children, when we have 5–6 experiments.	medium	medium: show principle of optics used around them (colour, polarisation) but also modern (cloaking)	medium	Open to everyone joining the Science Centre	No one present in the room (unless a group is visiting) to help the children with the understanding	~2,500 children visiting the science centre per month
LIGHTtalks: Careers in Photonics	Students, 18–25 years	promote and present Photonics as viable career for students and young professionals	Skills and venue for organizing events	70	500–5,000 / event	2–3 per event	30–300	medium	medium	medium	Modern format interesting for young people	Need for high-quality lecturers	150 participants at 2 events

Annex 6: photonics4All in a nutshell

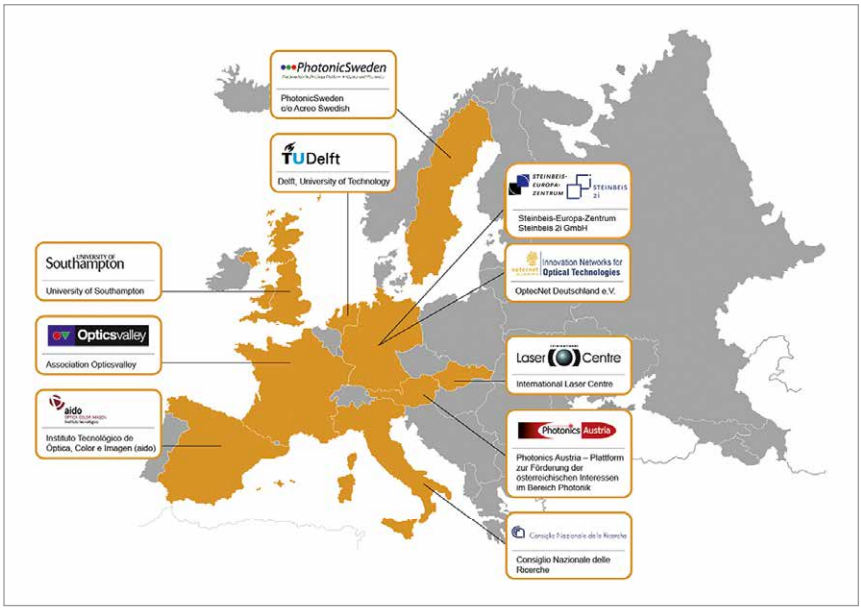
Photonics4All is a Horizon 2020 European Outreach project, funded by the European Commission[15] to promote photonics to young people[16], entrepreneurs[17] and the general public[18] across the EU. Photonics4All has developed a set of new promotional tools and applied them during a wide variety of outreach activities with different audiences.



Discover our unique approach and check out our tools and event at www.photonics4all.eu!

15 http://ec.europa.eu/index_en.htm
16 http://photonics4all.eu/young-people/
17 http://photonics4all.eu/entrepreneurs/
18 http://photonics4all.eu/general-public/

Annex 7: Photonics4All consortium & contacts



Nota Bene: The Spanish partner of Photonics4All, AIDO, went bankrupt during the project and thus, unfortunately, could only contribute to the project at the beginning

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Today, optics and photonics technologies have an important impact on nearly every area of our lives, covering a wide range of applications in science and industry. Photonics has been recognized as a Key Enabling Technology (KET) by the European Commission. However, despite its importance photonics is still not well-known to a majority of people.

To challenge this general lack of awareness about photonics, the European Commission funded the Photonics4All outreach project which was designed to promote photonics and light-based technologies to young people, entrepreneurs and the general public throughout the EU. Between January 2015 and December 2016, 9 Photonics4All project partners developed a set of promotional outreach tools which were used successfully during a variety of different outreach activities with over 400,000 people. The project aimed to engage the target groups with photonics and photonics applications, and inspire a greater interest in photonics amongst all those taking part.

This handbook summarizes our best practices in promoting photonics and light-based technologies to young people. The handbook is aimed at all those public and private organizations willing to organize outreach activities for young people, and should be useful to newcomers or those more experienced in science communication.

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