PROCEEDINGS OF SCIENCE

The Physics Project Days - A workshop to promote gender equality in physics

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The Physics Project Days are a four-day workshop for female high school students to encourage them to study physics, but above all to give them the self-confidence that they are capable of doing physics. Through hands-on experimentation in various physics disciplines, including particle physics, laser physics, plasma physics, and nanoscience, participants engage with cutting-edge research topics. The Physics Project Days undergo a rigorous evaluation to ensure its effectiveness and won the equal opportunity prize of the University of Hamburg in 2020. As of today, the Physics Project Days happen in four different locations: Kiel, Hamburg, and Aachen in Germany and Louvain-la-Neuve in Belgium. The main elements of the workshop, as well as selected results of the survey will be discussed.

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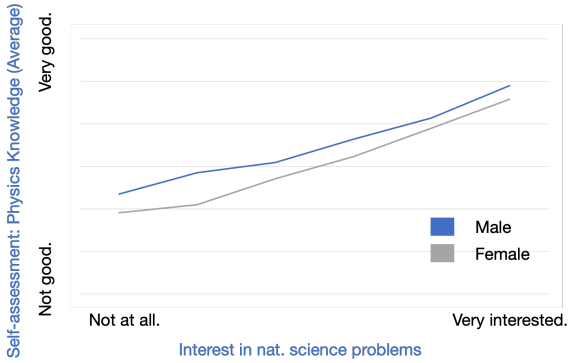

Figure 1: Survey at 8 schools in Schleswig-Holstein in Germany with the question to rank your interest in science problems and the self-assessment of the physics knowledge correlated among each other. Blue line is for male and grey line for female school students.

1. Physics is also for girls

Gender equality work is a major challenge, especially in physics, due to the highly distorted gender ratio, from enrolment figures to professorships. Since the imbalance is already serious at the start of studies, the origin of this discrepancy is not exclusively to be found at universities, but also at earlier stages of the educational pathway at school and in society. The promotion of girls' interests in scientific issues is essential for their choice of education and studies. This choice depends on the interest and the knowledge at the end of the school. A survey at high schools in Schleswig-Holststein showed that even if girls have the same interest in scientific questions they self-assess their knowledge in physics lower than the boys (Fig. 1). The girls assume that their capacity in physics (no matter the actual grade) is not good enough to study physics. The Physics Project Days were developed in 2011 at the Christian-Albrechts-Universität zu Kiel to show school girls that they have enough knowledge in physics, that they are not alone with their interest in physics and that physics is for everyone. As of today the Physics Project Days happen in four different locations: Kiel, Hamburg, and Aachen in Germany and Louvain-la-Neuve in Belgium.

2. The concept

The Physics Project Days (PPD) are designed to promote enthusiasm for scientific and technical issues and for physics itself among schoolgirls. An important aspect is to show them that many other schoolgirls share their interest in physics. The participants have the opportunity to get to know women who work and teach very successfully as researchers at the university. The contacts and networks established are intended to reduce the barriers to start studying in the natural sciences, technology, engineering, and mathematics (STEM). Through the PPD, the schoolgirls get to know the university environment, which also encourages them in their decision to study physics. Finally, another aspect of the PPD is to raise awareness of the topic of gender equality among researchers at the university by mentoring female students, but also by organizing the event in the research groups itself.

The target group of the PPD is female high school students in their last three years before university with an existing interest in natural sciences. School performance in the field of physics is

not considered. The restriction to the last three years of school ensures that the girls are independent and motivated and are already interested in university. This also sets a baseline of scientific topics one can assume they are familiar with to be used as a starting point for the research projects.

The PPD are held as a four-day workshop for female high school students, where they come to university to do a small research project with scientist from the university. The PPD create a safe space without any gender specific competition where the participants can try out themselves without any judgement from male school colleagues.

The participants have the opportunity to experiment on a research project of their choice. With individual supervision from scientific staff, they work on physics questions in small groups. At the end of the PPD, a final ceremony takes place in which the participants have the opportunity to present the results of their research to the general public. Parents, friends, and teachers are explicitly invited to the final colloquium. Furthermore, employees of the institutes and other interested parties are also very welcome.

The workshop happens in the first week after the summer break, such that the participants don't miss exams in school and that they do not need to decide between the PPD and holiday with family and friends. The project starts on Wednesday afternoon and ends on Saturday afternoon for the parents to participate in the ceremony and presentations on the last day. The general timetable is presented in Fig. 2. During the project phases 1-4 (light blue) the participants experiment and work on a research project with the supervisors. The last project phase 5 on Saturday morning is to prepare the poster for the presentation on Saturday afternoon. The supervisors are mainly PhD students or Postdocs, sometimes accompanied by master or bachelor students. The projects happen in the national language or in English, making sure it is indicated on the webpage when the participants choose the research project. An overview of the research projects is discussed in Sec. 2.1.

An important part of the PPD besides the research projects is the supporting program. This program aims at informing the participants about studying physics at the corresponding university and promoting networking beyond the school boundaries. More information about the supporting program can be found in Sec. 2.2.

In addition, it is important that the PPD are free of charge, which includes catering, accommodations and travel to the event. Only around 30% would participate in the event if the accommodation would not be paid and only around 65% would participate if there would be a cost of 50€ to participate. Keeping the PPD free of charge is important such that everyone can participate no matter the financial background.

2.1 The research projects

Each of the girls does one research project during the four-day workshop. When registering for the event they give a preference of three research projects which are described on the corresponding website. The topics of the research projects are covering the different research fields at the corresponding university from, e.g., particle physics and gravitational waves over nanoscience and laser physics to plasma physics and quantum physics. A lot of the projects can be re-used for advanced lab courses, lecture demonstration, exercises to lectures or internships. In the research project "Search for the Higgs boson" the participants analyse actual data from the CMS experiment and with that being able to reproduce almost completely the plot of the discovery of the Higgs boson

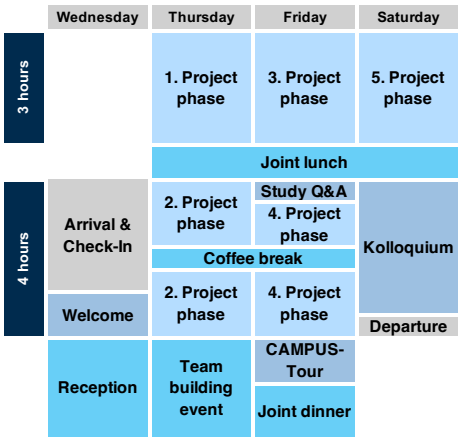

Figure 2: Time table for the Physics Project Days.

with the CMS experiment in 2012. In the research project about laser physics, they can learn how to build a laser, or how to use laser systems to detect gravitational waves. More information about the different research projects can be found on the individual websites [1].

2.2 The supporting program

The PPD offer a diverse supporting program to give the participants the chance to ask questions about studying physics, to visit the research campus and labs as well as to form a network across schools during the team building event.

In the **welcome session** on Wednesday, after the welcoming words, a couple of female researchers present themselves. Each of them telling what they research, how they ended up in their current position and what they like or find fascinating about physics.

On Thursday, the PPD offer a **team building event** in order to foster the networking between the participants. The team building event is a sportive activity where the participants are able to strengthen group cohesion through obstacle courses and overcoming the fear of height creates shared moments and a lasting bond between the participants.

On Friday, one hour is reserved for an **info session** about studying at the university. A professor, a PhD student and master or bachelor students participate such that questions at all levels can be answered. A small presentation about the bachelor studies at the corresponding university is done and the rest of the time is left for questions from the participants. These range from "How much math do we need to do?" over "How can I study a semester abroad?" to "Where can I work later and how much do I earn?". In addition, **a campus and lab tour** is organised in order to show the participants where the research is done and how many divers research projects in physics are on a campus.

3. The impact on the participants and the institute

The PPD undergo a three step survey to ensure its effectiveness. The participants are surveyed on the day of arrival, on the day of departure and three years later to assess the long term effects.

[1] https://taplink.cc/physikprojekttage

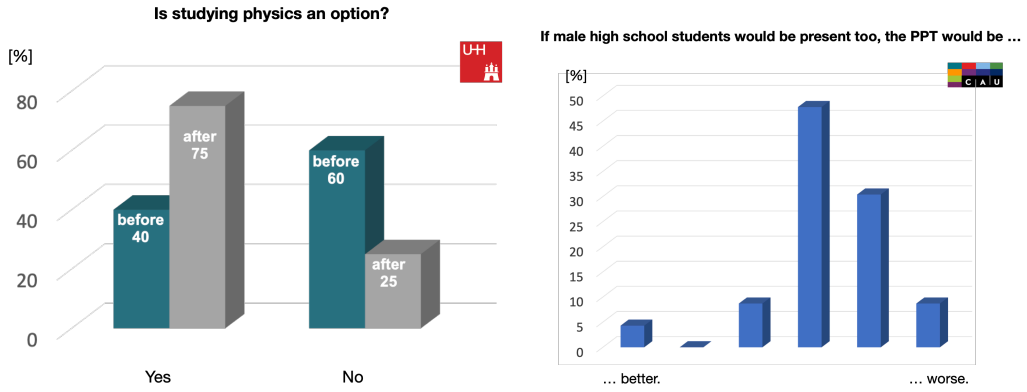

Figure 3: (left) The result to the question: Do you consider studying physics right before (teal) and right after (grey) the Physics Project Days. (right) The result to the question: If male high school students would be present too, the PPT would be better or worse.

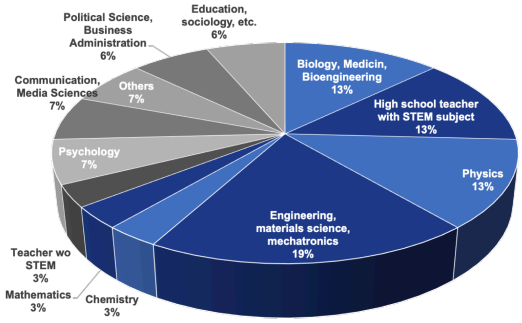

Figure 4: Three years after the PPT we ask the participants where they ended up. Most of the participants end up in a STEM related field (blue).

In the following a couple of selected results are present. Each result is presented for a specific location, however, they are representative for other locations as well.

One of the questions that is ask before and after the PPD is "Do you consider studying physics?". While before the event only 40% of the participants consider studying physics, after the event 75% of the participants consider studying physics as shown in Fig. 3 (left) with numbers from Hamburg.

The participants are also asked if the PPD would be better if also their male colleagues would be able to attend. The results are show in Fig. 3 (right) with the numbers from Kiel. While a small percentage thinks that the PPD would be better (it would be like a free of charge class trip), the majority thinks it would be worse. To cite one of the participants: *„Good [that it is only for girls], because you get not intimidated by male school mates.“*

Three years after the PPD we ask the participants what they are doing now and if the PPD had a significant impact on the decision. As can be seen from Fig. 4 (numbers from Kiel) 67% end up in a STEM related study. In addition, over 50% of them said that the PPD significantly influenced their decision. Another long term effect is that the awareness for topics related to equal opportunity and diversity in the host institute is increasing.

This workshop also has a lot of visibility outside the university. First of all, the participants say that they have a positive picture of the university and would participate in an event from the university again. The participants often need to present their research results in the schools as justification to miss the school. This brings the topic of equal opportunity back to the schools. The Instagram channel (@physikprojekttage), where stories and posts in cooperation with the universities are done, reach over 5.500 people. But also local and national press, such as newspapers and TV, are coming to the event to report about the activity, which creates good visibility for the university.

4. The funding

The PPD would not be possible without the support from the university, funding agencies and the members of the participating institutes. In the following we list the sponsors that participated in the past, e.g. for a start-up funding and the ones that still actively contributing for each location.

Kiel: DFG Collaborative Research Centres (CRC) TR24, 677, 1261, KiNSIS, and CAU Kiel.

Hamburg: Claussen Simon Stiftung, Verein Freunde und Förderer der Physik, Exzellenzcluster Quantum Universe, Light and Schools, and UHH.

Louvain-la-Neuve: Vice-rector for student affairs, sector for science and technology, NAPS, ELIC, CP3, the school of physics, and UCLouvain.

Aachen: ML4Q, CRC-TRR-257, RTG „Physics of the heaviest particles at the LHC“, Jülich JuLab and Ernst-Ruska-Center.

5. Summary

In summary, one can say that the Physics Project Days help to increase the self-confidence of the girls to study physics or a male dominated subject, show them that they are not alone in being interested in physics, change the picture of a physicist and their work and create awareness for the topic in the institutes.

A quote of a participant points out that: *„Thank you for the opportunity to participate here! Never thought that physicist are so cool. Unforgettable days!“*, showing that the stereotype picture of the physicist changed.

But also *„In the STEM field, I think it's very good [that the event is only for girls] because I don't feel like an outsider there as a woman and I'm encouraged that it's normal to be a woman in the STEM field.“* shows that the PPD show them role models in physics and that you are not alone as a woman that is interested in physics, stressing the point of creating networks across the schools and even across the countries.

In addition, *„You learn more than school physics and you see the labs, where you could work later. In addition, you get to know people interested in physics and recognise that you are not alone.“* shows that it is also important to give them the perspective of what to do with the studies and how a possible career path looks like.