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Attracting Women into STEM Studies – Girls Camps for School Students

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Abstract

Female students are still underrepresented in science, technology, engineering, and mathematics (STEM) studies in many European countries [1]. For this reason, the project "Girls Camps – Career Opportunities in Chemistry and Physics" was initiated to attract female high school students into Bachelor programs of chemistry and physics. The project focused on four-day science camps which are presented in this article. Center stage was given to an activating, professional and supportive learning environment and to female chemists or physicists at the beginning of their careers since research studies showed that learning experiences and role models are decisive for female students' choice of studies [1]. During the camps, school students thus attended a course at the XLAB – experimental laboratory for young people, in which they performed experiments with advanced laboratory equipment and got rapid assistance only when required and visited female scientists at the university as well as in companies. To prepare those for their important mission as role models, they had received a special training in advance. The evaluation of the first camp revealed that school students especially appreciated the hands-on experience at the XLAB and the conversations with the role models about their work-life balance.

Keywords: *STEM, vocational orientation, promotion of women*

1. Introduction

Since women are still underrepresented in STEM studies, extracurricular venues should take advantage of their facilities to promote women. For this reason, a project focusing on multi-day science camps specifically for female high school students was initiated at the XLAB – Göttingen experimental laboratory for young people. In the first place, the aim was to attract girls into chemistry and physics studies of the University of Göttingen which supplied the start-up funding for the project. The broader long-term objective now is to provide on the one hand a refined camp design which can be applied in school student laboratories worldwide and on the other hand implications for further educational research in order to tackle the problem of the gender gap in STEM in practice and theory.

2. Methods

Design-based research according to Collins et al. [2] and specifically one circle of the design, implementation and evaluation of the girls camp (s. Fig. 1) was collaboratively conducted by chemistry education researchers and teaching staff of the XLAB who regularly perform chemistry and physics camps.

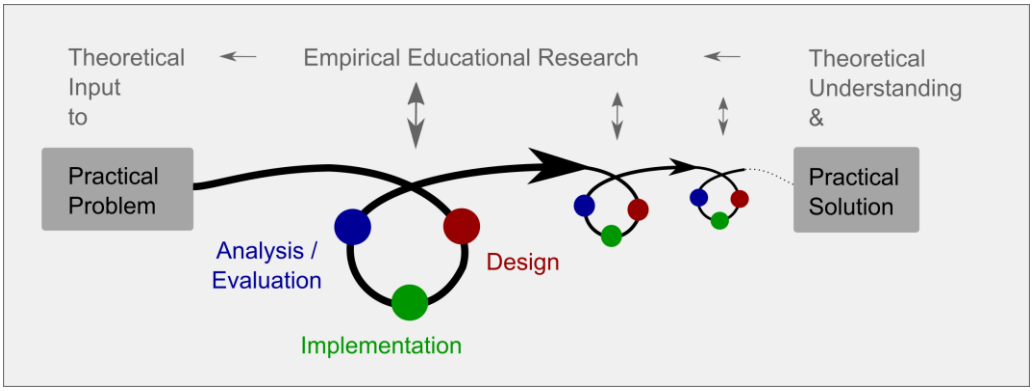

Figure 1. Design-based research process.

2.1 Camp design

The camp was developed mainly based on the following empirical educational research results:

1. Female role models and learning experiences were decisive for female STEM students' choice of studies [1].
2. Women in STEM must face many family-related challenges [3].

These findings and attempts of other groups which provide evidence that an experimental camp can increase the interest of students to pursue a STEM career [4,5] were the reasons for the design of a vocational orientation camp which gives central stage to *an exchange with female role models and a good experimental experience*: Thus, school students perform experiments in a professional, stimulating and supportive environment in the first camp part which specifically activate school knowledge required for the second camp part in which role models give insights into their scientific work at the university and local companies and into their career paths. At the end of the camp, school students gain information about STEM study programs and can discuss them with university students.

To prepare the role models for their important task, chemistry education students developed a special 30-minute training for them – a role model school which takes place immediately before the camp starts and deals with:

- reasons for the lack of women in STEM
- studies emphasizing the positive effect of role models on female school students' decision to study STEM
- guidelines for the interactions with school students

2.2 Camp implementation

The first camp was carried out on the topic of laser physics with eleven participants at the XLAB, the University of Göttingen and a local company in December 2019.
At the XLAB, school students performed experiments with open laser systems (s. Fig. 2) to figure out the function of individual laser components and the special properties of laser light. Then, they worked with optical tweezers which capture small objects like cells with laser light.

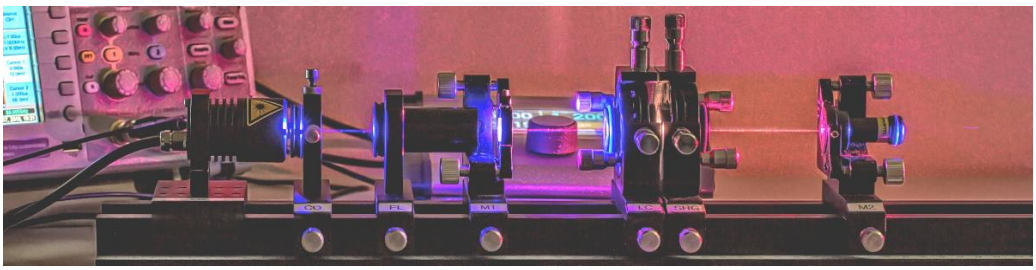

Figure 2. Set-up of the laser experiment at the XLAB.

At the University of Göttingen, the girls visited three female role models in their laboratories. One of these scientists demonstrated them how she investigates the dynamics of cells with optical tweezers for a deeper understanding of the extreme elastic deformations taking place in the human body, e.g. with belly skin during pregnancy. The other two physicists explained them how they use laser pulses to prepare and investigate materials for a new generation of solar cells. Afterwards, school students discussed with the role models about managing life as researchers and mothers.
At a local company, school students could observe lasers preparing optical systems for many different applications and got the chance to ask a female Product Line Manager who studied physics about STEM career opportunities in industry.
Finally, school students attended a talk about the Bachelor program of physics at the University of Göttingen and had a lively conversation with female physics students about it.

2.3 Camp evaluation

The camp was evaluated within the framework of a Master project of a chemistry education student [6]. She used *qualitative and quantitative methods of empirical educational research*, in detail a pre- and post-camp questionnaire and a group interview, to answer the following questions:

1. *Does the camp increase school students' interest to study physics?*

2. *How do school students assess the experiments and the role models of the camp?*

Pre- and post-camp questionnaire: Eight items with a *five-point Likert scale* which were self-designed or adapted based on the instrument of H. Itzek-Greulich were chosen [7].
Considering that the camp participants decided themselves to attend the physics camp, they might have been much more interested in physics than typical school students. Being aware of this possible measurement artifact, another questionnaire testing the interest in physics was constructed and answered by the camp participants and a control group. This group consisted of thirteen school students who participated in a regular XLAB course which is booked by the teacher and not the students. The items for this extra questionnaire were adapted *based on items of the PISA study 2015* about the interest in natural sciences [8] and of H. Itzek-Greulich [7].
Group interview: The interview was performed after the camp by means of *guiding questions* such as: Can you imagine a career path similar to the one of the physicists you met today? Afterwards, a transcript of the interview was generated. Finally, a *qualitative content analysis according to Mayring* was conducted.

3. Results and discussion

The questionnaire revealed that the interest of the school students to study physics was directly after the camp (t_2) not higher than before (t_1) (s. Tab. 1).

	Example item	Number of items	Testing time	Mean value	Standard deviation	Cronbach's alpha
Interest in physics	I like to acquire new knowledge in physics.	8	t_1	1.88	0.75	0.92
			Control	2.23	0.95	0.94
Interest in starting a physics study or career	I will need good skills in physics in my future profession.	8	t_1	2.49	0.78	0.85
			t_2	2.50	0.70	0.80

Table 1. Questionnaire results: Number 1, 2, 3, 4 and 5 mean I agree, I rather agree, I neither agree nor disagree, I rather not agree, and I disagree, respectively.

Taking their high interest in physics at the beginning of the camp into account (s. Tab. 1), one could assume that almost all already planned to study physics before participating so that the camp could simply not further improve their interest in studying physics. However, the fact that the interest of the control group in physics was not significantly lower indicated that the assumption is not right. The interview confirmed this indication. Extract of the interview transcript (translated to English):

It was actually already clear to me before that I definitely don't want to study pure physics.

Research showed that career decision-making is a process [9]. Therefore, it is rather unlikely that school students have reversed their decision to not study physics immediately after some days in the camp. However, the interview indicated that they might do after some time in which they have reflected the camp experiences, as it provided evidence that the experiments and exchange with the role models in the camp encouraged them to start a science career.

I always thought you had to be especially smart to study physics, because it would be totally complicated, but the physicists, we mainly talked to women here, they told us that you can do it even if you're average.

I don't just think that experiments can be done at the university that you don't have in the classroom, but that at the university you immediately have this connection to the application.

It was good that they [...] always encouraged us that family life is possible during study and a science career.

The results of a group who conducted a camp comparable to the one presented in this article were similar: Pre- and post-camp survey showed no significant increase in participants' interest in a science career, whereas in the follow-up survey 87 % of the participants stated to plan a STEM or health-related career [5].

4. Conclusion and outlook

The project evaluation indicated that a camp which offers experimental experience and an exchange with female role models can contribute to the closing of the gender gap in STEM and probably has the strongest impact on school students who have not already made a clear decision for or against studying STEM. Hence, the project confirmed empirical research findings about role models (s. section 2.1) and pointed out the demand for studies addressing the following questions: At what age do most girls make their choice of study? What is the consequence for girls camps?
The project has been continued within the framework of the public outreach project of the Collaborative Research Center (CRC) 1073. To further refine the camp design and theoretical outcomes, more camps including circles of re-design, implementation and evaluation will follow. All three circle components will be improved: Female role models who have children will be preferred, because the camp participants asked about their strategies to balance scientific work and family life. Moreover, advertisement will declare that the camp targets school students who do not know what they want to study. If possible, the next evaluation will include a follow-up questionnaire.

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