Improving the learning environment in the Department of Physics: a peer mentoring program for first-year female physicists alongside changes in the lecture program

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Abstract

In 2018, a D-PHYS evaluation of the Basisjahr (first Bachelor year) pass rates showed an imbalance of the pass rates between genders in the first and second attempt: the pass rate for female students was only 32 % compared to 46 % for their male colleagues. There was also feedback from female students to staff about problematic challenges during this first-year experience. In addition, the number of women starting the physics course was low, only 17% of the first-year students in 2020 (e.g., 45 out of 250). These factors raised concerns and questions, and an investigation was undertaken in 2019 to examine the first-year learning experience and to identify if there were issues that could be influencing the gender imbalance in pass rates. The study involved 21 interviews of randomly selected students (11 women and 10 male students) who had successfully completed the first year in the last 12 years.

This article describes the outcomes of these interviews, and the measures that resulted from this study. The interviews showed a distinct difference in experiences of the genders in the first year, and a consistent highlighting of problematic issues in the learning environment. In 2020, changes to the first-year physics learning environment followed, with a particular focus on a project to improve the situation for the female students. First, a peer-mentoring program was established for first-year female physics students. We report on how and why we established the program, the events that took place during the academic year 2020/2021 and present the evaluation data. Second, a number of changes were made to the physics lectures and exercise classes in 2020, which were designed to improve the learning environment for all. Finally, and in parallel, an anonymous grading system was introduced, to ensure that the differences in pass rates were not affected by unidentified biases. The paper concludes with a reflection on the impact of these multiple measures, an outline of plans to expand peer mentoring to all first-

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year students, and the importance of an ongoing evaluation to examine the effectiveness of the changes introduced.

Introduction

The undergraduate Physics program at ETH Zurich starts with the “Basisjahr” during which the first-year students' study together with the mathematics students. The first year is intended to bring all students to the same academic level, whether they come from varying specialisms in high school, different countries, or have different prior knowledge. Everyone is given the chance to study physics, as there is no selective entry. However, they must pass the “Basisprüfung” at the end of the first year to continue with their degree. The entry procedure at ETH contrasts with other universities, which have entry exams, or require minimum grades at the end of high school study, to be allowed entry to physics. Each year a large number of students start physics (in 2020 it was 245 students) (Figure 1a), and many drop out or fail the first year. This paper outlines how a study of the first year in D-PHYS came about, the factors and issues identified, and how this led to initiatives to improve the situation in the first year for female students and the learning environment in general.

In 2016, the Department of Physics, after examining the challenges of the first-year study, decided to split the “Basisprüfung” (ETH pilot programme) from having all eight exams held at the end of the summer semester, to setting the first three exams after the Fall semester and the remaining five at the end of the academic year. The idea was to reduce the pressure on the summer exam session and to provide the students with an early feedback. However, the evaluation report on this measure showed that the failure rates of female students in comparison to their male colleagues increased significantly afterwards (see Figure 1b). A difference in pass rates between the genders existed since 2009, but the gender differences increased after the split exam initiative, and in 2016 and 2017 more than 40% of female students failed (Rütsche et al. 2019). In addition, there had been verbal feedback from female students to staff members about problematic challenges in the learning environment during their first-year experience. A small working group was founded to seek to identify underlying causes and potential differences in their experience, which might be affecting the results of the female students.

As a first step, confidential interviews were designed and conducted with 21 students and graduates from different genders, years and background. We used open-ended questions, which enabled the participants to speak about their first-year studies freely. We wanted to identify if there was a difference between the male and female experience, and also to find the common themes. The interviews showed that all of these students described the learning atmosphere as very challenging. The female students, however, were much more affected by the environment, isolation and the impact of failure, than the male students. This led to two of the initiatives that will be presented in this article: the establishment of a peer mentoring program for female students and a number of adaptations to the first-year physics lecture program. In parallel, an anonymous grading system was also introduced into the first-year courses.

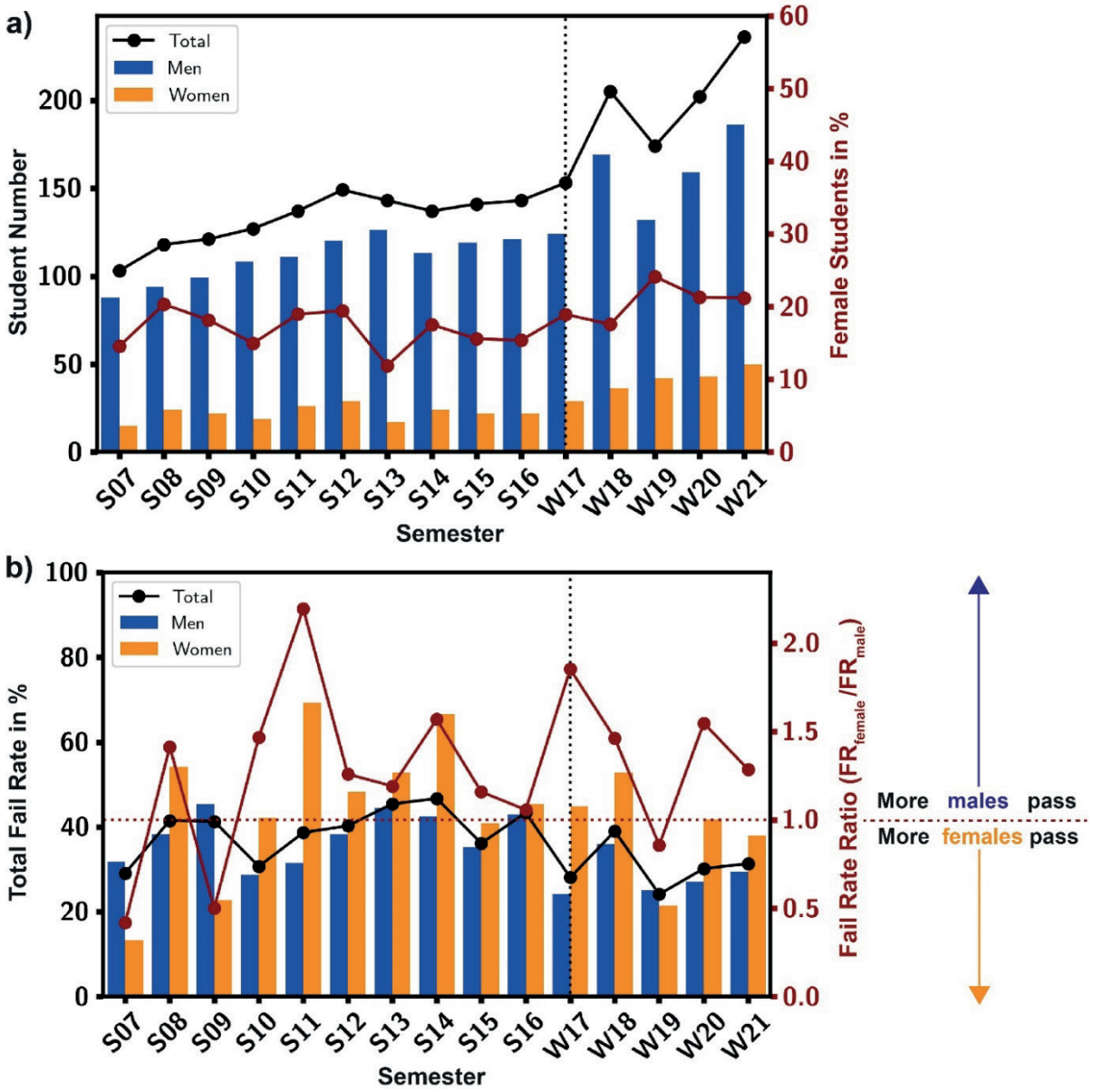

Figure 1: Student Number and Failure Rate a) Number of male (blue) and female (orange) Physics students since 2007 and the corresponding percentage of female students (red, right axis). b) Total failure rate of Physics students at Basisprüfung in % (black, left axis) and corresponding ratio (red, right axis). Percentage of male failed at the first attempt in the Basisprüfung (blue) and of female (orange). Values above 1.0 mean that more males pass and values below 1.0 mean that more females pass.

Interview Evaluation and Suggested Measures

The students interviewed had all successfully completed the first year in Physics at ETH Zurich, their starting dates ranged from 2008 to 2017. Some interviewees needed to take the first year twice. We spoke to bachelor and masters' students, PhDs and Postdocs. The 21 interviews were with 11 female and 10 male students. This was a qualitative study, undertaken in order to identify potential issues, whether in the teaching and the learning environment, or related to gender issues.

The interview questions were designed to make no assumptions about the first-year experience or gender differences, but rather to focus on aspects of the first-year course in general for example: "Describe how you experienced your first two weeks on the physics

course and in the exercise classes?", "What was the student environment like?" or "What contributed to you passing or failing the Basisprüfung?"

All interviewees gave feedback on a number of challenges in the teaching and learning environment. For example, concerning the lectures, students appreciated that there was an established curriculum in Physics, which stayed constant over many years. However, when the lectures depended mainly on the personality and approach of differing professors there could be a negative impact on the learning outcomes and student exam success. Many interviewees reported that there had been a culture of teaching only to the geniuses; and this was perceived as demotivating and intimidating. Certain professors had stated this aim specifically, alongside the comments like “only 50% of you will be here next year.” All students spoke about the lack of an introductory period and the overwhelming start to the lecture program.

Criticism was levelled at the exercise classes that accompany the lectures, both in terms of content and the level of teaching. A major criticism was about the excessive time that it took to solve the exercise sheets related to each class. For example, in the Analysis course, it took even the very good students a minimum of eight hours per week to do the exercises. In addition, it was not possible to understand or solve the questions asked in the exercise sheets in all classes without an explanation from their assistants. Plus, the students experienced very different levels of teaching quality between different exercise classes and assistants. A further pressure came from the fact that the Basisjahr can only be repeated twice, two failures means that you cannot study physics at any other university in Switzerland.

On a positive level, the Department of Mathematics and Department of Physics offer jointly a study center since 2015, where students can solve their exercise sheets with colleagues and ask questions to teaching assistants[5]. This center was considered to be extremely helpful for the students, because it provides the possibility to get individual feedback to a student's problem. In addition, the student association (VMP) was explicitly pointed out as very useful and helped in many ways to make students feel welcome in their studies.

However, the interviews did reveal gender differences in the experience of the first-year students. Most female students were affected by what they described as a competitive and unwelcoming environment and by male colleagues who went around saying how great they were and how easy the first year was. Very talented women, who had been top of their school classes, were deeply affected by the abrupt change in their experience of being excellent at school, and of entering an unwelcoming, alienating and intense environment. They described a serious impact on their self-confidence, creating a fear of failure which made them doubt their abilities, and which intensified their reluctance to ask questions so as not to appear stupid. Many woman students spoke of the overwhelming start, with little introduction and perspective, and how awful it was for them to admit when they were in difficulty and ashamed to reach out for help. Top male students struggled with this adjustment to university too, but their self-confidence was unaffected. The male students outlined how they took the difficult year step-by-step and even if they failed, they described the year as painful, needing to be better organized, or better taught. The male students insisted on having extra-curricular activities while most women were more likely to give up their free time activities for constant studying. A further factor that impacted the female students was the heavy dropout rate of their female peers, which added to loneliness and isolation (Marshman et al. 2018).

[5] An article about the Study Center can be found on page 13 of the ETH life magazine of September 2016: https://ethz.ch/content/dam/ethz/associates/services/News/life/ausgaben/deutsch/eth_life_16_3_DE.pdf

Multiple recommendations from the interviews

Based on the outcome of these interviews, the working group discussed a number of measures which could be implemented practically to improve the learning atmosphere in the physics studies for everyone. One early idea was to introduce a pre-study welcoming week with group forming activities and pre-math courses that could give the students the feeling of being welcomed, find friends and adjust the different prior knowledge levels before the course started. Also, we suggested that adjustments could be made to the introductory weeks of the courses giving the students time to adapt to the new system and the new ways of learning. The exercise classes, sheets and teaching could be restructured. However, as the starting point of the study had been to examine the experiences of the female students and, given the differing impact of the experience and the exam results, a support measure for them was deemed to be a priority.

All interviewees spoke of a challenging and unsupportive learning environment, but the impact on the women students needed to be addressed. Examples from US universities show that making the learning environment deliberately welcoming for all groups increases academic success and participation. For example, Harvey Mudd College[6] in the US has increased its gender representation, and successful performance with specific inclusive measures, creating a welcoming learning environment for all, which resulted in graduating 50% male and 50% female physics students since 2016 (Harvey Mudd College 2018). Research also shows that in physics, women can be struggling not only with self-confidence issues, but the phenomena of "stereotype threat"[7] that comes from feeling out of place, and self-doubting in an environment, which is traditionally populated by male students, and as a consequence underperforming (Johnson 2013). The working group therefore recommended the immediate implementation of a peer mentoring program for first year female students, given that it was clear the women students needed support and networking in the learning environment.

However, given the commonality of the feedback about problems in the learning environment, we also argued for the introduction of wider adjustments to the lecture program outlined above. There is always the possibility that female-only initiatives can lead to a backlash from the other students or lead to the women feeling disempowered by having to receive special treatment. It was, therefore, extremely positive that a number of the additional measures to improve the learning environment for all were implemented immediately, and in parallel, with the new mentoring program. With the support of D-PHYS and the two National Centres of Competence and Research (NCCRs) it was possible to implement two significant measures in 2020: the establishment of a peer mentoring program for female students and a number of adaptations to the first-year physics lecture program.

Establishment of a Peer Mentoring Program

The Departments' conference approved a peer mentoring program for first year female students in Spring 2020. In designing this program, and arguing for its implementation, we had explored initiatives to support female physics students at US universities such as MIT, Yale, Stanford and UCLA. We also examined research that showed the effectiveness of introducing such peer mentoring programs in STEM fields (Zaniewski & Reinholz 2016). We learned some practicalities from a similar program established in 2016 at D-MAVT at ETH (ETH Zurich/D-MAVT n.d.). It was always intended that a focus on the female students would be a first step, and if successful, the program would then be extended to all first-year students.

[6] Harvey Mudd College is a private university in the US, whose President Maria Klawe (since 2006) is an advocate for supporting diversity and women in STEM subjects.

[7] Prof Anthony Johnson, University of Maryland, defines Stereotype Threat as "the anxiety people experience when they fear that their academic or job performance might confirm a negative stereotype about their gender or ethnic group."

The first action was to set up an information and registration webpage to contact and inform both possible mentees (female students starting their first year in Physics) and mentors (female bachelor, master, and PhD students). The webpage design went through a consultative process, involving the student associations, VMP and Phimale[8]. VMP had established a peer mentoring program for all students in 2012 and we ensured that information on the existing VMP program was cross linked to the new D-PHYS webpage. The plan for the academic year was to match mentors and mentees, facilitate a regular one-to-one meeting process and organize a number of networking events throughout the year.

The webpage[9] includes the purpose of the program, a brief description of the content of the program (events and activities), registration forms for mentees and mentors respectively. It is also illustrated with regularly updated welcoming photographs of women networking (ETH Zurich/D-PHYS n.d.). Considerable thought was invested into a user-friendly registration process for mentors and mentees, and how they might be matched and connected. The university is a multilingual environment, attracting students from neighbouring countries. The online registration questionnaire asks potential mentees or mentors to give information on mother tongue, hobbies, specialism in secondary school, origin and on their expectations of their role or their mentor's role. Mentors were asked to specify how many mentees they would coach.

The program began in Fall 2020 with two email invitations sent: one to all new first year female students and the second to the potential female mentors in D-PHYS. Initially more mentors signed up than mentees and the registration remained open to incorporate latecomers. 44 mentees, which is almost all of the new female students, and 43 mentors from D-PHYS signed up to the program. Just before the semester course began, the students were matched to their mentor and entered the program.

It was originally planned to run this whole program face-to-face, but many of the offered activities had to be adapted to the ongoing Covid situation. The new adaptations were developed spontaneously to give better support to the participants in the online world. For example, the program organizers set up an online/open-source chat platform ("Element") at the beginning of the semester to enable the mentors and mentees to get in contact quickly and to ask and answer questions regarding their studies or life in Zurich: such as "Which is the most helpful book for Analysis?" or "Where are the best parties in Zurich?".

[8] Association for Mathematics and Physics Students (VMP) has been established for more than 75 years. https://vmp.ethz.ch/en/home/. Phimale, the association for female Physics students, was established as an association for equal opportunities, as part of VMP in 2017, http://phimale.ethz.ch/

[9] The webpage of the peer-mentoring programme can be found here: https://www.phys.ethz.ch/studies/mentoring.html (accessed 30.08.2021)

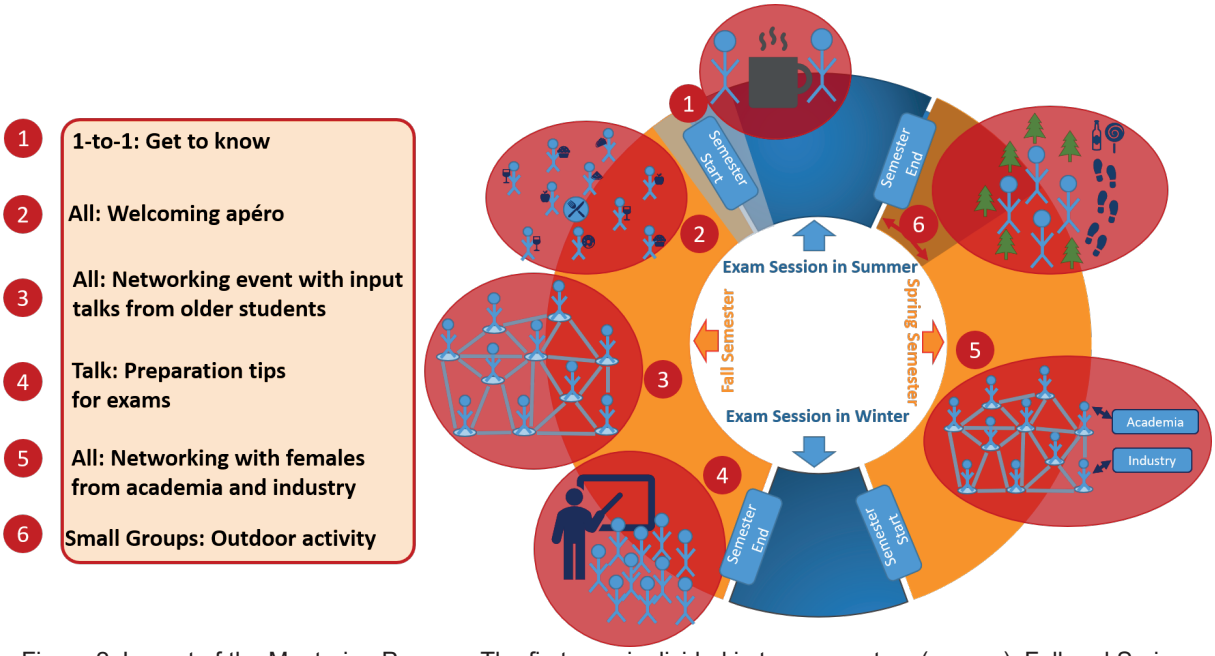

Figure 2: Layout of the Mentoring Program The first year is divided in two semesters (orange), Fall and Spring, and two lecture free periods (blue) during which the exams take place. Full details of events 1 to 6 are in the text.

We encouraged the mentee and mentor to meet at least once per month. To support the individual meetings, we planned six activities to take place throughout the year. Figure 2 gives a visual schema of the program, with the activities organized throughout the year. It was intended that one activity would be organized by the student associations, but the Covid pandemic changed the structure of the programme. Each event is summarized below giving its purpose and implementation details for each event.

1. **Get-to-know:** Coffee vouchers were offered to the participants to encourage them to meet as soon as possible at the ETH campus restaurant. They could post about the meeting on the online platform to inspire the others to go for coffee together, and to establish the community spirit. Most of the mentee-mentor-pairs met before or just shortly after the semester start.
2. **Welcoming apéro:** We were able to host an in-person apéro shortly after the semester start. The COVID-situation required strict measures and that the event take place outside. It took place on a sunny day, attended by the mentees, mentors, the program sponsors and organizers and the professor who taught their first physics course. Small details were important: a welcome speech, name tags for all, a get-to-know someone game (participant number: 51).
3. **Networking event with input talks from older students:** The second event had to be organized on Zoom, because of the worsening Covid situation. Two students shared their personal stories to give the first semester students an insight into the experiences of the older students. The purpose of the event was to network, to enable questions on study challenges: a Zoom poll was used for interactivity, and two sessions of break-out rooms enabled the attendees to network and exchange with each other (participant number: 27).
4. **Preparation tips for exams:** Before the exam winter session (Jan 2021), Viola Vogler-Neuling (program organizer and also former exam corrector) organized an online meeting presenting the structure of the exams, some tips how to go about exam preparation and how to take them successfully. The first semester students had the opportunity to ask questions (participant number: 32).
5. **Networking with women from academia and industry:** During the Spring 2021 semester three women from academia and industry were invited to a networking event online. The women presented their career paths to the program participants and gave insight into their successes and struggles. It was a lively and interactive event (participant number: 28).

6. **Outdoor activity:** The last event was a treasure hunt held outside to be performed in pairs or small groups. The location of the treasure hunt was the Hönggerberg campus, i.e. it was not required that the women travel or take a long time off to participate and it fit the ongoing Covid restrictions (participant number estimated to be 20 as no registration was required).

The participation in the program was steady, and an evaluation process was designed to gather information on its impact, failings and to learn lessons for any continuation of the program.

Evaluation of the Program

We set up a first online evaluation survey at the end of Fall 2020. It was important to get feedback early, because most interaction was online, with participants working in home office. There were 35 respondents and we could see the level of engagement, participation in the activities and received feedback on issues related to the online platform, and the Covid regulated apéro. It was positive to see how many mentees and mentors had connected.

At the end of the academic year 2020/2021 we sent out a second online survey to gather feedback on the mentoring program. 37 participants responded to the survey; 50% were mentees and 50% mentors. The survey was designed to evaluate successes and problems under the following themes; how often our pairs met, how they rated the way they were matched, the experience of the organized events and how it was to be a mentee or mentor. Were there some missing aspects in the program? We learned that on average the mentees/mentors had 3 one-to-one meetings over the year, but some met as many as 14 times. The matching characteristics in terms of age, study-type, matching ideas on work-life balance and future perspectives were the highest rated for making a successful pair. Feedback on the organized events was very positive, but respondents would have preferred in-person meetings. The exam tip event was vital to some mentees, while all appreciated the networking. There was differing feedback depending on whether you were a mentee or mentor. Mentees dropped out of the program if they changed course, or failed their exams, but all wrote of feeling in good hands, supported and reassured. Mentors enjoyed supporting the mentees and dealing with challenging questions. It was sad to deal with the experience of their mentee leaving the program, sometimes with no explanation. The mentors benefited from the women in industry event and would like an introductory event, before the program starts, to advise them on their roles.

Longer term evaluation of the program, and its impact on female students, will be necessary. Given that the peer mentoring program will be continued and extended to all first-year students in Fall 2021, all lessons learned and feedback from this first year will be passed on to the next stage, with the aim to continue monitoring and evaluating the impact of a peer mentoring program on the first-year students, specifically the minority group of female students and their subsequent exam results.

Adaptations to the First Year Physics Course

Many findings from the interviews led to immediate changes to the Physics 1 course in Fall semester 2020. Physics 1 has weekly lectures of two times two hours over 14 weeks, taught by the professor. The lectures are accompanied by exercise classes, of two hours, taught by the teaching assistants (TAs), and one TA also is present at the Study Center once a week. The course adjustments involved changes in the lectures, development of a new strategy with the exercise classes and sheets, and a specific briefing meeting of the teaching assistants for the course. All changes were designed to improve the teaching and learning environment for first year physicists.

The adjustments can be classified into three categories: First, there is a long tradition and belief in the student community that the first year is designed solely to fail 50% of the students. This influences the learning environment negatively putting pressure on all students and if, added to this, there is the myth that only geniuses can pass the first year, then the learning environment is neither inclusive nor supportive. The first step was to make very clear that the purpose of the first year is to bring students to the same level of knowledge, given their range of backgrounds and prior knowledge. No one should say (as had been said in past years) 50% of you will fail, or that the course was "trivial." An informal meeting between the students and the professor was held to create a friendly environment from the beginning.

Secondly, the structure of the exercise sheets was analysed and adjusted, based on the feedback that there is an overwhelming learning experience at the beginning of the course. There were a number of new features. The sheets were embedded in the broader course context by having a learning goal attached to each sheet. Then sheets were designed deliberately to build up gradually the application of knowledge and skills presented in the lectures. Each sheet began with the easiest exercise giving the students the time to practice. In the first three weeks students had to solve only 3 exercises per week, increasing the number to the normal 5 exercises after that. Students were also informed that they could change exercise classes if the one they were assigned to was not suitable.

Thirdly, the teaching assistants (TAs) were given information and support before the course started. Many PhD students have not studied at ETH and do not understand the purpose of the Basisjahr. They were advised on the outline of the course, what was important to create a good learning environment, and recommended to attend the ETH "Learning to Teach" course for TAs. A list of "dos and don'ts" highlighted common demotivating mistakes, such as diminishing the difficulty of the task and preventing students from asking questions. An additional support for exercise classes was also introduced, where the TA visiting the study center, provided the other TAs with information on the common student problems of the week, one day before their next exercise classes.

The fact that the outcomes of the study could be implemented so quickly into the next semester's course was related to the great investment made in innovation by the responsible professors, and the dedication of working team members in D-PHYS.

Introducing an Anonymous Grading System in Physics 1

Independently from the initiatives discussed above, it was decided to introduce an anonymous exam system for the first-year physics course as a response to the analysis of the exam results published in 2019 (Rütsche et al. 2019). The aim was to ensure that the gender differences in the exam results were not due to any bias on the part of exam correctors. Anonymous marking was implemented for the last three Physics-I exams (W20, S20 and W21). A further reason was to demonstrate to all students the commitment of the Department to an unbiased treatment of the assessment process and reducing the impact of extraneous factors on the assessment.

In the new system an exam dossier consists of an envelope labelled with an individual exam number, containing a cover page, the exam questions and a formulary leaflet. Students were required to enter their full name and their personal student ID number on the envelope and cover page only and to label their submitted answer pages with the corresponding individual exam number only. At the end of the exam, the students were asked to insert the cover page, questions sheets and their answer pages back in the envelope. After collection, the exams were scanned by an independent individual, who then separated envelope and cover page from the question-and-answer pages. The latter were transferred to the correction process. Each question was corrected, double-checked and marked by a team of 2-3 teaching assistants who had been involved in teaching exercise classes for the lecture. Grading was done, after counting the total score, but before the exams were re-assigned to the student's personal ID number.

In many universities internationally, anonymous marking is now the norm. In Sweden, for example, all universities use this approach; the University of Lund established an anonymous marking system in 2015 (Lund University/Faculty of Engineering n.d.)[10]. There is ongoing research about the impact and efficacy of anonymous exams on performance (Hinton & Hinson 2017, Akveld & Luethi 2022), with more findings expected in the future. In the meantime, it is helpful for minorities to know that stereotypical views have been removed from the assessment process, perhaps also reducing stereotype threat.

A first analysis of student failure rates in 2020/2021

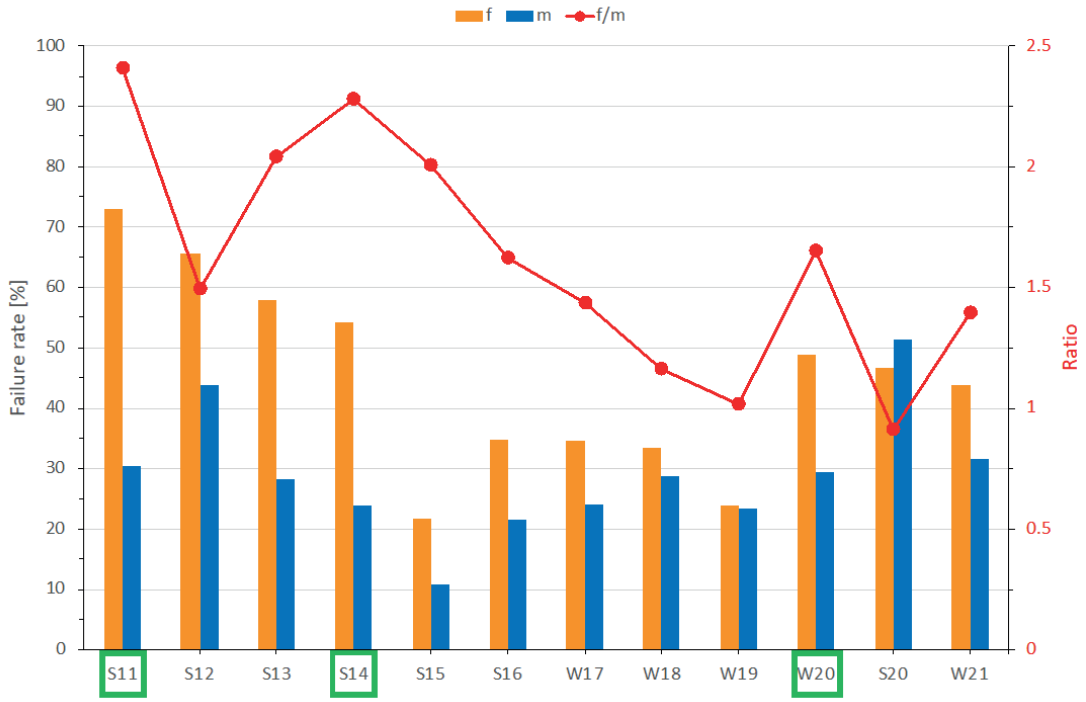

Figure 3: Failure rate of Physics students at the Physics 1 exam over the last 10 years (females in orange and males in blue). The ratio between the failure rates of women and men is shown in red (right axis). The years with first time lecturer are indicated by green squares.

Figure 3 displays students' failure rates in physics in the last 10 years and shows the ratio (FR_female/FR_male) of failure rate (FR) between women and men. When focusing on 2020/21 the absolute differences (|male-female|) in % are as follows: 19.3 % in W20 (202 students) and 12.4 % in W21 (240 students) compared to the 10-years average of 18.2 %, without implementation of anonymous marking (Figure 3). For students in mathematics, the difference between women and men was 19.9 % in W20 (157 students) and 17.6% in W21 (155 students) compared to the 10-years average of 19.3 % without anonymous grading. Perhaps the anonymous grading format had a limited effect on gender difference, but it is very important to test this assumption over a longer period.

In addition, in W21, the gender difference decreased more between students in physics than between the math students (compared to W20). Is this the result of the peer mentoring program introduced in W21 for female students in physics? This program was not available for male physics students nor math students.

[10] University of Lund introduced anonymous marking in 2015.

Interestingly, the gender difference in failure rates was reversed for S20 for the first time in 10 years. The change during the Covid lockdown in spring 2020, when much of the learning process was online, led to a difference of 4.6 % for the Physics exam in S20 in favor of the female physics students and 5.6 % in favor of the female math students. A change in the learning setting and the gender difference was canceled or even reversed. In S20 only the written exam was on-site. Is it possible that women suffered less without the negative experiences of the learning environment in this semester and exam preparation? Another hypothesis is that women dealt better than male students with the difficult situations arising from Covid and could get better organized.

The analysis of the gender differences of the Physics 1 exam and the “Basisprüfung” is only at the beginning. It should also be noted that the accuracy of analysis is also difficult to establish, because the teaching teams for each course change on almost a yearly basis, which increases the parameters influencing the pass rates. One factor that has been observed is that failure rates in general were always highest in the years where the teaching team was new (green squares in Figure 3). In their successive years the failure rates were decreasing.

Conclusion and Outlook

This paper has outlined responses to a study initiated by D-PHYS in 2019, driven by a concern for gender differences in the exam results at the end of the first year, and negative verbal feedback from female students to staff members on their first-year experience. The study confirmed the concerns and, supported by the department, the two NCCRs and involved professors, it was possible to implement a number of measures quickly in the subsequent academic year of 2020/2021. The implementation of measures both to improve the learning environment, and to support the minority female students has only just begun. The female peer mentoring program was embedded within wider goals, and long-term objectives, to improve the first-year learning experience for all students.

The evaluation processes for the first peer mentoring program for female students indicated successful participation from mentors and mentees, with some suggestions for amendments, particularly that networking would be better face-to-face, once we are through the Covid pandemic. These two evaluations were first steps, and the evaluation process needs to be continued into 2021/2022, when a peer mentoring program in the first year will be extended to all new students, with the support and resources from the Department of Physics.

A first analysis of gender differences in the failure rates between male and female students in the first year was made, using the latest exam results, but a deep and lasting analysis of the changes in yearly results will take time and further investigation. It needs to be an ongoing process to assess the impact of the introduction of new measures to improve the learning environment, the establishment of the anonymous grading system, and the specific support for female students. A change in the gender differences of the exam results has been observed, but it is difficult to identify what brought this about: changes to the learning environment, the peer mentoring program for female students in physics – and there is a difference in results between physics and math – or some impact of the online teaching and learning environment during the pandemic.

One concern that set into motion the original study, was to identify if the first year in physics at ETH was a difficult environment for young women physicists. While only based on a relatively small cohort, these interviews did clearly identify challenging experiences for all female students interviewed and, for some, it was a time when their confidence was destroyed. The fact that all the interviewed students identified problems, lead to a focus both on what could be done in general to help students and, at the same time, to provide support for the women

students. Emphasizing only a minority's status and presence can add to factors such as "stereotype threat" or jealousies if all students are struggling in a challenging academic year, but only one group is supported.

Now that the peer mentoring program will be extended to the whole student group in the coming academic year, the impact of this program on all the students, and the learning environment, needs a next-stage evaluation. As part of this evaluation, it will be important to investigate if there are any losses to the minority group of women, through the extension of the program to the whole cohort. The D-MAVT's peer mentoring program for female students has only recently been extended to all of their first-year students; it may be that lessons can be learned and shared across the departments.

Ongoing investigations of exam results will continue, to identify the longer-term impact of the measures introduced into the first-year learning environment. It could also be useful to connect this analysis to the results of the regular student evaluations of the first-year lectures and courses. It might also be enriching to connect the work in first-year physics, with the ongoing exploration and development of the curriculum in first year D-MATH courses (Akveld & Luethi 2022).

In conclusion, this paper has reported on how a 2019 study of the first-year physics experience resulted in the introduction of a range of initiatives and measures in 2020/2021. All three initiatives were aimed at improving a learning culture for the young students in the department. As the changes continue to be embedded and expanded, the evaluation process should continue over time. A future quantitative study of student experiences could be undertaken and would be very valuable, to check the impact of introducing these measures on the current and next cohorts of students.

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Bibliography

Akveld, M. & Luethi, M. (2022). Reflections on Diverse and Inclusive Teaching. *ETH Learning & Teaching Journal*, Vol. 3, No. 1, 2022.

Chowdhury, S., Klauzner, I. & Slonim, R. (2020). What's in a Name? Does Racial or Gender Discrimination in Marking Exist? IZA – Institute of Labor Economics, IZA DP No. 13890. Online: https://www.iza.org/publications/dp/13890/whats-in-a-name-does-racial-or-gender-discrimination-in-marking-exist (accessed: 19.08.2021).

ETH Zurich/D-MAVT (n.d.), Mentoring for first-semester students. Online: https://mavt.ethz.ch/studies/mentoring-for-first-semester-students.html (accessed: 19.08.2021).

ETH Zurich/D-PHYS (n.d.). Mentoring for Physics Students. Online: https://www.phys.ethz.ch/studies/mentoring.html (accessed 19.08.2021).

Harvey Mudd College (2018). Harvey Mudd Graduates Highest-ever Percentage of Women Physics and Computer Science Majors. Online: https://www.hmc.edu/about-hmc/2018/05/15/harvey-mudd-graduates-highest-ever-percentage-of-women-physics-and-computer-science-majors/ (accessed: 19.08.2021).

Hinton, D. & Hinson, H. (2017). A large-scale examination of the effectiveness of anonymous marking in reducing group performance differences in higher education assessment. *PLoS ONE*, 12(8), 2017. Online: https://doi.org/10.1371/journal.pone.0182711

Johnson, A. M. (2013). Combatting Stereotype Threat. *Optics and Photonics News*, Issue May 2013, pp. 14-16.

Lund University/Faculty of Engineering (n.d.). Anonymised assessment and exam registration. Online: https://www.lth.se/lthin-english/anonymised-assessment/ (accessed: 19.08.2021).

Marshman, E. M., Kalender, Y., Nokes-Malach, T., Schunn, C. & Singh, C. (2018). Female students with A's have similar physics self-efficacy as male students with C's in introductory courses: A cause for alarm? *Physics Review Physics Education Research*, 14, 020123(17). DOI: 10.1103/PhysRevPhysEducRes.14.020123

Rütsche, B., Altherr, W., Deiglmayr, A., Dittmann Domenichini, N., Kapur, M., Kortemeyer, G., Schlienger-Merki, C., Schubert, R., Stern, E. & Vaterlaus, A. (2019). Bericht zur Pilotphase mit geteilter Basisprüfung: Weitere Ergebnisse für den Studiengang Physik. Zusatzdokument zum "Bericht zur Pilotphase mit geteilter Basisprüfung: Evaluation basierend auf den Eintrittsjahrgängen 2016 bis 2018". ETH Zurich internal document, 29.10.2019. ETH Zurich.

Zaniewski, A. M. & Reinholz, D. (2016). Increasing STEM success: a near-peer mentoring program in the physical sciences. *International Journal of STEM Education*, 3/14. Online: https://doi.org/10.1186/s40594-016-0043-2