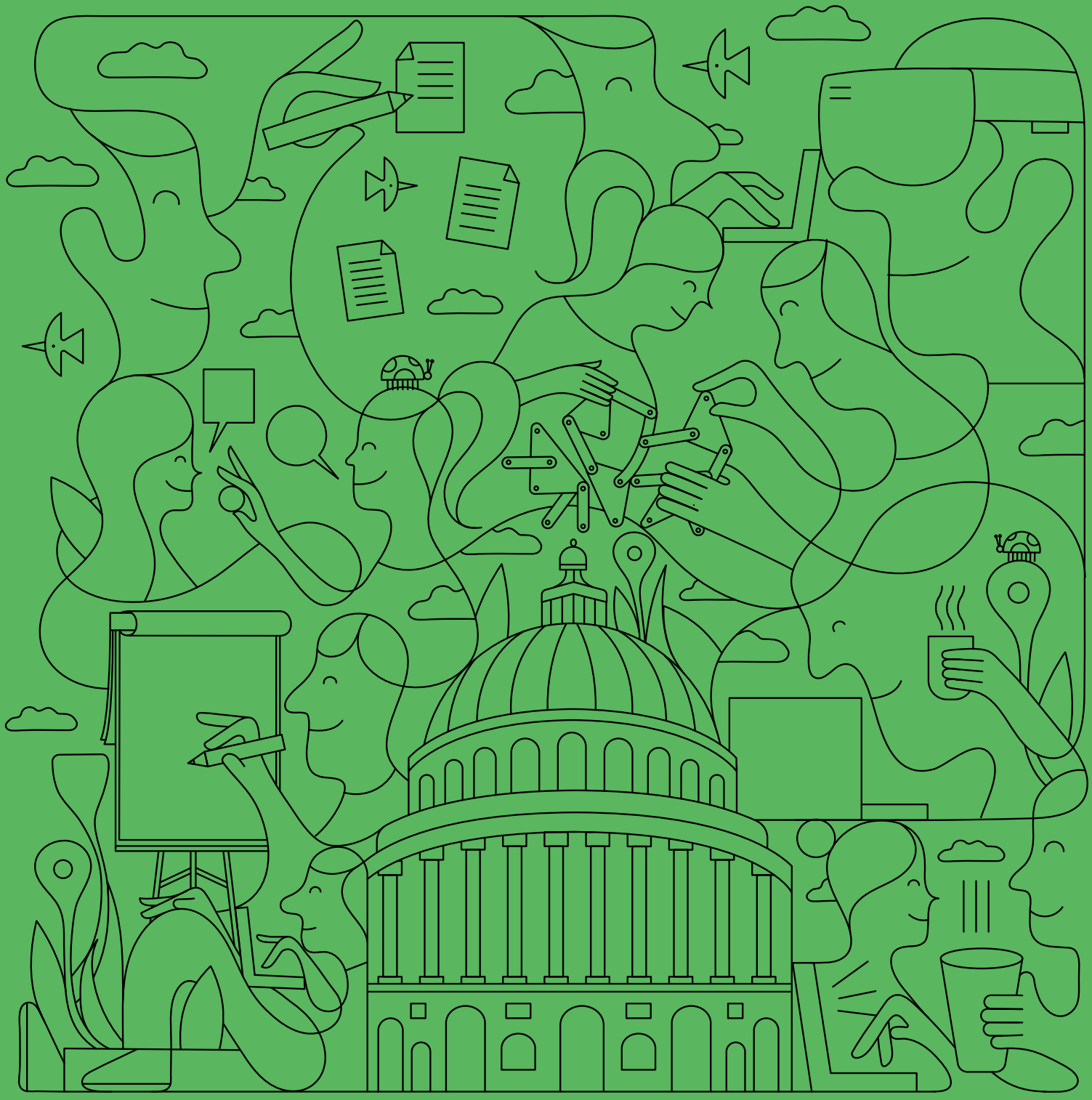
ETH zürich

Innovative Teaching 2020

Independence



Dear readers,

Right as this second edition of the report on innovative teaching was ready to go to print, the pandemic broke out. Practically overnight, teaching staff had to reinvent their courses to make them suitable for remote learning online.

Fortunately, those of us involved in teaching were able to build upon our experience: We are already well-practised in the flipped classroom format, for instance, in which students learn the basic principles themselves before attending classroom sessions. At the same time, our students are used to working independently in teams to develop solutions for complex problems.

There was thus no need to rework this report either, as it already highlights formats and tools that focus on taking initiative and applying knowledge in practical settings. In other words, teaching formats that empower our students to acquire personal and social skills: skills that are no less crucial for a successful career than technical expertise and methodological abilities.

The coronavirus crisis reminds us that we do not know what the challenges of the next 30 to 40 years will actually look like when they arise – but we can still give our students the skills they will need to master them.

I wish to thank all the teaching staff who are implementing these formats with such great dedication. Anyone inspired by reading this report can contact one of the academic departments' educational developers or the Educational Development and Technology (LET) administrative department at any time. They would be happy to help implement new ideas for teaching.

Professor Sarah M. Springman
Rector, ETH Zurich

How ETH Zurich fosters independence

Critical thinking, creativity and self-motivation: these are the skills ETH wants to cultivate in its students. This is crucial if the students are to become professionals who will be able to solve problems in the future – problems whose nature remains unknown. All across the university, there are numerous tools and initiatives that seek to further this goal. They range from project-oriented curriculum courses and interdisciplinary design thinking workshops to means for supporting student-driven initiatives.

Projects in the curriculum

Pages 6 – 19

Robots, diving aircraft or bioreactors for phage w: project work that involves building prototypes is common at ETH. Students work closely together in teams to generate ideas, foster team spirit, obtain financing, make plans, practise teamwork, develop designs and implement them – largely independently. The Focus projects run by the Department of Mechanical and Process Engineering are one example. Others aim at participation in international student competitions like the International Genetically Engineered Machine Competition (iGEM).

Innovedum, the fund for innovations in teaching

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Under the auspices of the Rector, this programme supports projects that further develop teaching at ETH. ETH Zurich finances innovative teaching projects through the Innovedum fund, and embeds aspects such as independence and critical thinking in the curricula across disciplines.

Interdisciplinary project weeks

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ETH students from different courses of study work in small interdisciplinary teams to come up with their own proposals for answering current challenges, such as climate change, urbanisation, waste management or energy supply. Applying the design thinking approach, they practise solution-oriented creativity, working in groups and critical thinking. These initiatives include the large-scale ETH Week for 180 Bachelor's students, the ETH Singapore Month for some 20 Master's students, and various summer schools.

Space for personal initiatives

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Students have space to work on their own extra-curricular projects in the Student Project House. Anyone who has an idea should have the opportunity to test it out here. By providing Pioneer Fellowships, each endowed with 150,000 Swiss francs, ETH Zurich joins with the ETH Foundation in supporting the development of innovative products or services based on scientific work. This grants young entrepreneurs the chance to spend 12 to 18 months getting their products ready for the market. Pioneer Fellows receive support from the Innovation & Entrepreneurship Lab (ieLab), including a network of coaches who themselves have successfully founded companies.

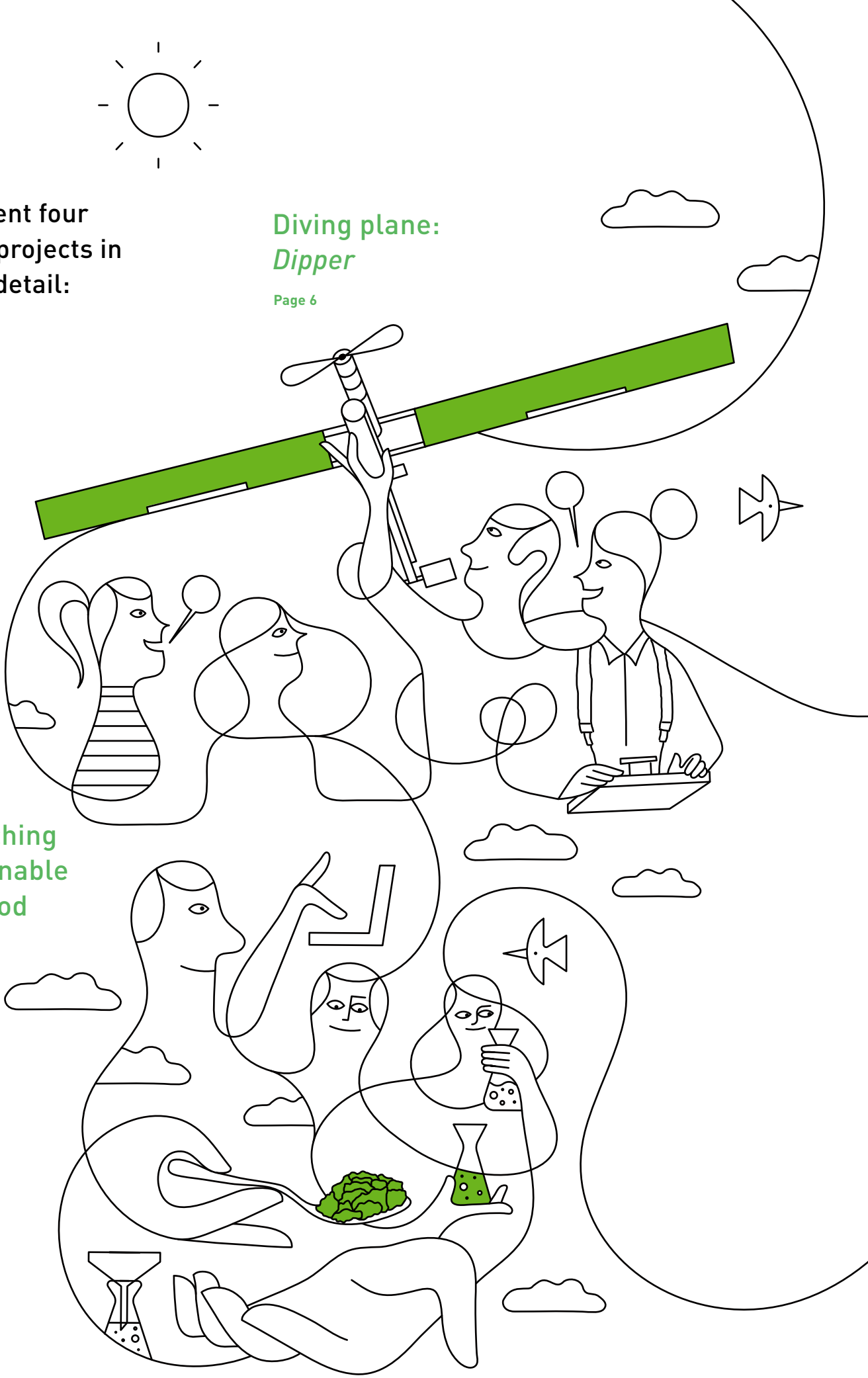
… plus a few ideas in the pipeline

Pages 40 – 41

We present four student projects in greater detail:

Diving plane:
Dipper

Page 6



Researching a sustainable superfood

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Boston-bound with
a self-made bioreactor

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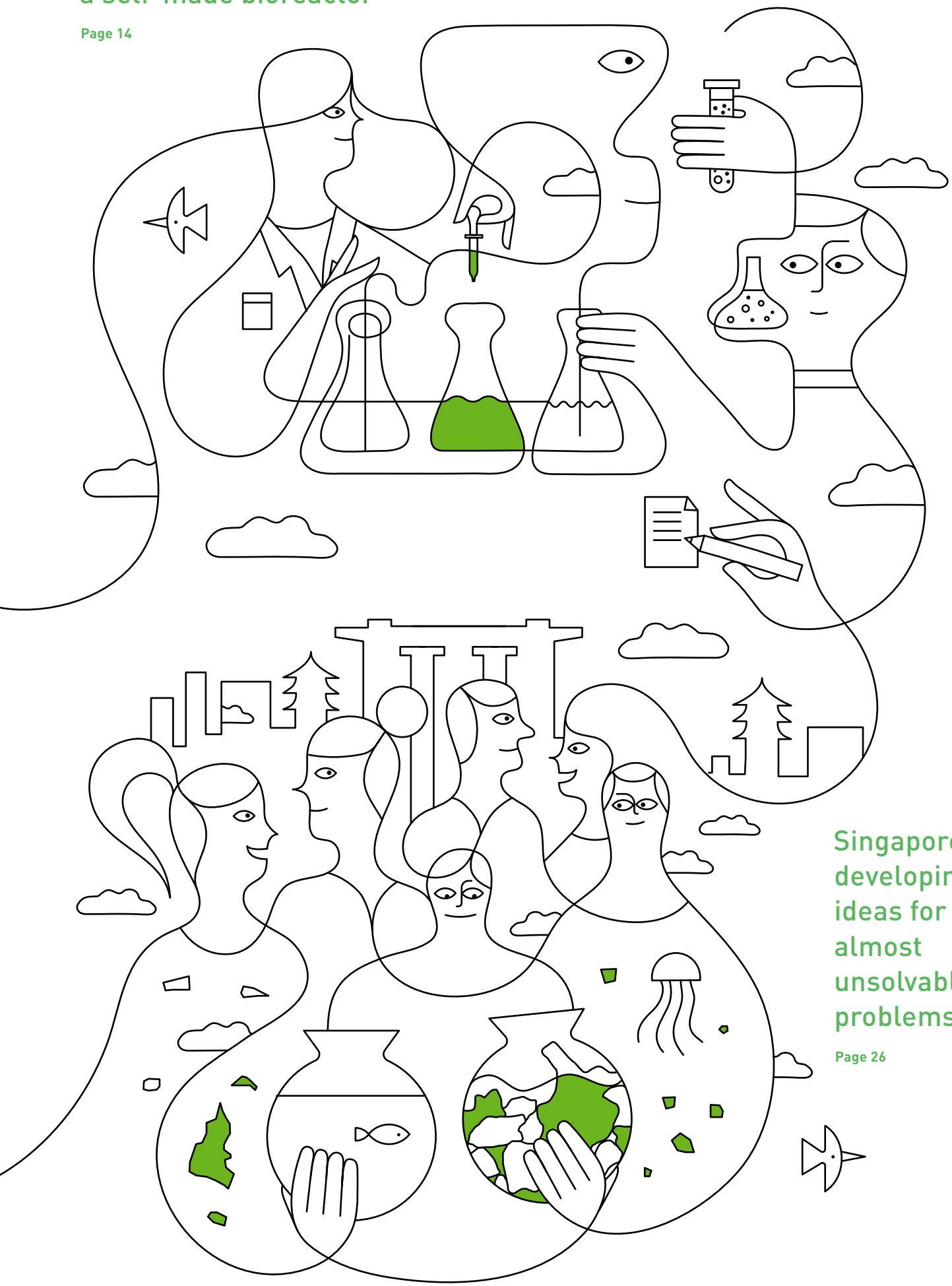

Singapore:
developing
ideas for
almost
unsolvable
problems

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PROJECTS IN THE CURRICULUM

Project-based teaching is becoming increasingly widespread. Focus projects originated at the Department of Mechanical and Process Engineering at ETH Zurich all the way back in 2006. Working in interdisciplinary teams, Bachelor's students have nine months to transform a clever idea into an innovative product. A similar task faces students who enrol in the Synthetic Biology 2 module and take part in the iGem competition.

Learning thanks to obstacles

Mechanical engineering students can put the abstract knowledge they have acquired into practice in what are known as Focus projects. Working in teams, they pursue crazy ideas – and break new technological ground, as illustrated by the development of the *Dipper* diving aircraft.

By Ori Schipper
Photographs: Stefan Weiss

→

Simon Jeger and Friedrich Rockenbauer working on the *Dipper* diving aircraft.

If the unadorned office with its cluttered desks along the walls looks a little drab, that just makes the showpiece stand out all the more: an aircraft measuring just over one metre in length that can not only fly, but can dive underwater. Eight ETH students – six mechanical engineers and two electrical engineers – have been beavering away on their "flying submarine" for the past year. It started off with a crazy idea – and the determination to "make something that didn't yet exist," says Simon Jeger, a mechanical engineering student and team leader of the Focus project, which goes by the name of *Dipper*.

His enthusiasm is palpable, and indeed contagious by virtue of his likeable nature. "Ever since I was little, I've always been fascinated by flying through the air and moving underwater, and so combining these two worlds in one project was particularly appealing to me," Jeger explains. The idea for his Focus project originated back in the spring of 2018 in discussions with various fellow students and Professor Roland Siegwart, the director of the Autonomous Systems Lab at the Institute of Robotics and Intelligent Systems. "We had dozens of ideas, but for feasibility reasons we agreed relatively quickly to take on this technological challenge," Jeger says.

THE IDEA OF A DIVING AIRCRAFT

Shortly afterward in May came the informational event, at which the fourth-semester students discover which Focus projects they can take part in the following academic year. Alongside five professors who presented their ideas – such as a flying wind turbine and a new exoskeleton for people with paraplegia – Jeger put forward his idea for a diving aircraft. His project aroused some interest. "Although the 14 credits don't cover the time that goes into them, Focus projects are popular all the same. Not all students who apply for them can actually take part," Jeger says. This leaves the professors who will be supervising the projects with the task of selecting students – and putting together the teams.

Jeger had only a passing familiarity with most of his colleagues before the project started, so at the beginning of Autumn Semester 2018, one of the jobs was to figure out a sensible way of dividing up the work such that everyone could bring their own specific strengths to the table. As team leader of the Focus project, Jeger was able to use the planning and leadership experience he had acquired in the military. For example, he was able to understand that although some team members engaged in the project more energetically than others, everybody was still part of the team. "The teamwork went very well – and was a lot of fun, too," Jeger says. He observed how the team members grew into their various roles as time passed.

Three sub-teams quickly formed in the *Dipper* project. The first group was responsible for finding the ideal structure of the flying and diving machine. Another member of this group alongside Jeger was Max Berger, a qualified design engineer with experience in 3D modelling. He finds it exciting to "begin with a blank piece of paper, with the challenge of constructing a mechatronic system that masters a previously unsolved problem," as he writes on the project website (dipper.ethz.ch). What emerged is an aircraft that – like gannets hunting for fish – can fold its wings back and accelerate to 130 kilometres an hour in a nosedive.

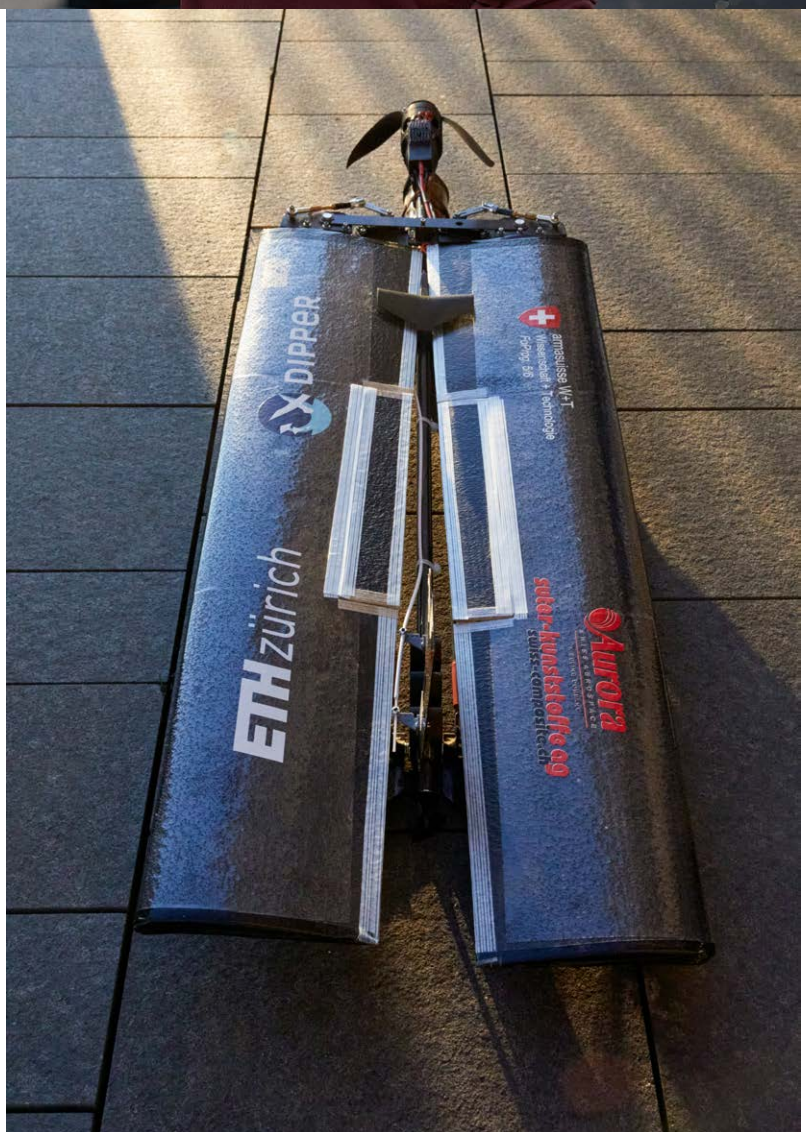
The second group developed various ideas for the propulsion. "At first we decided to go with impellers," Jeger says. Although this kind of propulsion, with a propeller encased in a tube-shaped housing, is used in aircraft and jet skis, the project team soon discovered that those applications involve completely different rotational speeds. "We realised that we wouldn't be able to produce enough thrust with the impeller to get the aircraft back out of the water," Jeger recalls. They needed another solution.

SINKING THE PREFERRED ENGINE CONCEPT

So Marvin Harms, who describes himself as the "propulsion guru" of the *Dipper* team, together with his colleague Noah Kaufmann, designed a hybrid engine in which a single motor is connected with both an airscrew on the tip of the nose of the aircraft and a screw propeller on the tail. Depending on the direction in which the motor is turning, it makes the front or the back screw rotate. Six weeks after the start of their work, the students gave the following update on the project website: "After sobering propulsion tests in the River Limmat, we chose to 'sink' our initial concept [...]. But the mood in the propulsion team recovered [...] after tests of our underwater screw chugging along in the Katzensee lake on a glorious autumn day."

The third group in the Dipper team was responsible for the control functions of the diving aircraft. This was where the two electrical engineers had a chance to shine. In the air, the diving aircraft could →

The aircraft can also dive underwater with its wings tucked in.



be controlled manually, but underwater this didn't work, because the water absorbed the signals both of the remote control and of the GPS coordinate system, Jeger explains. This meant that for the diving phase, they would have to program an autopilot and enclose it in a watertight capsule.

LOSING THE ELECTRONICS

At the tests in Bungertwies swimming pool in Zurich, which the students were allowed to use on Thursdays between 10 p.m. and 5 a.m., they soon noticed that their 3D printed prototypes were unable to adequately protect the electronics. "As most boat and submarine builders can certainly confirm, the battle to prevent water leakage is a significant challenge. Especially when water ingress is associated with a loss of electronics, as it is in our case," said the students in their diary entry for week 23 on the project website. Four weeks later, they exclaimed: "Those who believe that aircraft design is the pinnacle of mechanical engineering should first try and keep submersed electronics free of moisture!"

Thanks to their tenacity and inventiveness, the students finally managed to successfully seal off the electronics. In general, Jeger reports, the learning process was iterative, with the students learning new things when building all three versions of their diving aircraft. "When a complex problem seems unsolvable," Jeger says, "it can often be broken down into sub-problems that are easier to tackle." Looking back, it was also important for Jeger to learn that you don't always have to calculate everything to reach your goal. Some problems can be described well mathematically, while others are so complex that well-designed tests are more effective than modelling.

For Siegwart, who has supervised a wide variety of student projects since 2006, such statements prove that Focus projects are not only excellent opportunities for students creatively to implement ideas in practice, but also that this learning format shows emerging mechanical engineers what it means to be an engineer. "In the Bachelor's degree course, the students acquire very good technical foundations, but the knowledge often remains abstract," Siegwart says. "In the Focus projects, by contrast, they have to work things out and take carefully considered decisions about implementation. This often leads to 'aha' moments and deeper understanding."

> "The students have to take decisions about implementation. This leads to deeper understanding."
>
> Professor Roland Siegwart

INTENSE AND REWARDING EXPERIENCE

The Focus projects are, in principle, open to all mechanical engineering students, Siegwart explains, but they don't appeal to everybody. He deliberately relies on voluntary participation and thinks it is therefore only right and proper that only around 20 to 30 percent of students take part in a Focus project, not least because workstations are limited and coaching must be guaranteed. "We want engaged and motivated people: doers with drive and purpose, who see the value in their work and are willing to put a lot of energy into a project," Siegwart says.

When a Focus project finishes, Siegwart often hears students say they are happy that this intensive and strength-sapping phase of their lives is over, but that they see this time as having been extremely enriching nonetheless. And then there are always ideas that are subsequently pursued at Master's level, he adds. In addition: "Four start-ups have already emerged from Focus projects. One of these companies, Wingtra, produces drones that can take off and land vertically, and has created more than 70 new jobs to date."

UNEXPECTED OPPORTUNITIES

Dipper is still a long way off from any commercial applications, Jeger says. But theoretically he could see the diving aircraft being used to collect water samples – for example, to quickly estimate how far oil has spread after a tanker accident in a difficult-to-access region. And some unexpected opportunities have also arisen. The BBC, for instance, has expressed interest. They could potentially use the aircraft, which can plunge into the water like a gannet and leap out of it again like a penguin, to capture new images for their spectacular nature documentaries.

But for the moment, such prospects belong to the future. At present, Jeger is busy with his Master's degree. Yet Focus projects will not let him go that easily! In the new academic year, he is acting as coach to a team of students who want to develop a drone that can capture other drones in the air. Together with two doctoral students from Siegwart's research group, he meets regularly with the students, who are in the design phase at the start of their project and have to take important development decisions. Jeger listens to their deliberations and takes into account how feasible and practical the ideas are when giving his assessment. At the same time, he gives the students useful tips and bits of advice. "Often they're grappling with problems similar to the ones we had to solve," Jeger says. •

Dipper surfacing and taking off (video still).

CONTINUING EDUCATION

Experiencing challenges in developing countries

The core of the Master of Advanced Studies (MAS) in Development and Cooperation is located not on the university campus, but rather all around the world. Every year, it enrols 24 students, who go abroad after just one semester: Brazil, Haiti, Albania, Namibia, Kyrgyzstan and Thailand are just a few of the countries that the ETH students visited last year.

Under the leadership of Isabel Günther, Professor of Development Economics, and Programme Coordinator Fritz Brugger, the two-year continuing education programme prepares students for a career in international cooperation. The programme is aimed at highly educated professionals who want to apply their expertise to the field of global development. A Master's degree or equivalent in the humanities, a technical discipline or the natural or social sciences is a prerequisite for applying.

Brugger believes what most distinguishes the MAS is its strong focus on the practical. In the two semesters before and after the project assignment abroad, there are hardly any classroom lectures. "The size of the class allows for a highly interactive format that promotes dialogue," Brugger says. Great emphasis is placed on individual and group work. In the advanced training section, the students reflect on their experiences abroad and share them with the others in presentations, discussions and papers. The students also receive input on a broad range of topics from guest lecturers: conflict researchers, water experts and ethicists. "Challenges in developing countries are multidimensional," Brugger explains. "To understand the interdependencies, you need more than technical knowledge."

ON-SITE ASSIGNMENTS

For their assignments abroad, students spend eight to ten months working on a particular project. Should they need support, they can call on the course instructors as well as the mentor (a graduate of the programme) assigned to each of them. The range of projects is highly diverse: developing a system for sanitary facilities in Haiti, helping on a refugee programme in Lebanon, setting up crop insurance for Asian farmers, and more.

WITH DATA FROM THE REAL WORLD

Teaching machines how to think

They recognise human faces and voices, classify texts by their content or scan tissue samples for signs of cancer: self-learning algorithms are becoming more important in many fields. Joachim Buhmann, Professor of Computer Science at ETH Zurich, teaches the Advanced Machine Learning course, which each year attracts some 600 Master's students from a range of subjects.

During the week of lectures and conventional instruction, the students get to know various algorithms for supervised and unsupervised machine learning. They also carry out project work in which they apply current data from the real world. For example, they were asked to write an algorithm that would analyse brain scan images for signs of dementia and classify them by degree of severity. Not infrequently, the projects produce new approaches that students can further develop in a semester project or their Master's thesis. •

Distributing the project assignments functions like a reverse job market. As the programme organiser, the Center for Development and Cooperation (NADEL) sends the students' CVs to various partner organisations. These make an offer to the students they would need for a specific project. "In our experience, the students usually have several options to choose from," Brugger says. The partners are governmental development organisations, aid organisations, NGOs and foundations. The students receive no salary, but their travel and living expenses during their projects are covered by the Swiss Agency for Development and Cooperation (SDC). •

MATERIALS SCIENCE

From assignment to project

During the first semester of the materials science degree course, students conduct lab experiments only under close supervision and with clear guidelines – not least due to safety concerns. In their third year, the students take hands-on research courses and do their Bachelor's thesis. To ease this transition, lecturer Martin Willeke established a practical lab course. "With this practical course, we aim to make it easier for students to move from clearly delineated tasks to more open-ended projects," Willeke explains. The students solve problems in groups and relatively independently. For example, they may build magnetic scales that they will then use in later experiments. "They decide how to achieve their goal," Willeke says. They could use different materials, for instance – plastic bottles and Lego are popular choices. Students often opt to use polystyrene, too, but they soon discover it is ill-suited to this purpose, as it charges the material and thus distorts the results. "Mistakes like that are to be expected and are an important part of the learning process," Willeke says. •

MASTER'S IN CYBER SECURITY

Working with EPFL to prevent cyber risks

Cyber risks pose a major threat in our increasingly connected society. Hackers steal confidential data from companies, organised groups attack important infrastructure systems and states carry out targeted cyberattacks. Countering these threats calls for specialist knowledge and skilled experts. To encourage people to train as IT security specialists and cyber security researchers, ETH Zurich and EPFL launched a joint cyber security Master's programme in autumn 2019. Supported by the Swiss government, it is the first course of its kind in the country and helps ETH build on the success of the Zurich Information Security and Privacy Center, which was set up in 2003.

Topics covered include cryptography; hardware, software and network security; and methods for ensuring system security and earning user trust. Zurich students spend at least one semester in Lausanne to get a taste of activities at EPFL. "The course gives students a broad and well-founded cyber security education," says Professor of Computer Science, Peter Müller, who designed and developed the programme. Besides completing their Master's thesis and an internship, students undertake a semester project to apply their knowledge and independently solve a technological and scientific problem. •

Screenshot: Courtesy of Melanie Erzinger


FRAGILE

The centrepiece of the project: a bioreactor for phage therapy.

Boston-bound with a self-made bioreactor

An empty lab, a budget and a weekly appointment with supervisors: Students who enrol in the Synthetic Biology 2 module at the Department of Biosystems Science and Engineering at ETH Zurich in Basel organise their project work themselves.

By Andres Eberhard
Photographs: Stefan Weiss

It's October 2019, and eight young people are waiting around at Zurich Airport with a big wooden box at their feet. As they check their luggage and collect their boarding cards, they feel nervous. The reason for this anxiety is their precious cargo – the product of five months' work, including many late nights.

These travellers are students from the Department of Biosystems Science and Engineering in Basel. Inside the wooden box is a bioreactor they have built themselves. Their destination is the Hynes Convention Center in Boston, where the finals of the International Genetically Engineered Machine (iGEM) competition are taking place.

Every year since 2005, ETH has sent a delegation to this international contest, where students from all over the world present projects in the field of synthetic biology. The event is growing all the time: in 2019, there were over 350 teams and a total of almost 6,000 participants. A jury assesses the presented projects and awards prizes to the best.

MODIFIED PHAGES AGAINST BACTERIA

When the eight students get out of the aeroplane, they are relieved: the bioreactor has arrived intact. "We protected it with a lot of foam padding," says Cheyenne Rechsteiner, 25, a few weeks later. She is a Master's student in biotechnology and part of the ETH team. Constructed out of a metal frame, three bottles, several hoses, and many wires and circuit boards, the bioreactor is the heart of the project. It is designed to someday allow researchers to grow pathogens and bring them into contact with bacteriophages.

Phages are special viruses and the natural enemies, as it were, of bacteria. Properly used, they could provide an alternative to antibiotics. The problem is that natural phages are very specific and are effective against only a limited number of pathogens. That is why the ETH students set themselves the goal of modifying the phages so as to increase the number of variations. This could pave the way for therapy breakthroughs in the future. One day, the process could look like this: blood is taken from the patient and the pathogen is isolated and cultivated in the bioreactor. Next, the pathogen is exposed to a large number of phages, thereby revealing which phage can destroy the pathogen. This phage is subsequently used in treatment.

However, a library of lab-modified phages doesn't yet exist. Current practice is to isolate phages from nature and then characterise them. This is a very laborious process that the students want to simplify and improve, and they want to do that with the help of a phage library that detects the specifically effective phage in the bioreactor.

The subject the students have chosen is highly topical, as therapy with antibiotics is currently reaching its limits. More and more multidrug-resistant germs are emerging, against which conventional antibiotics are ineffective. In the worst case, simple infections will become life-threatening in the future. Consequently, research into phage therapy is experiencing a comeback. Although the approach was discovered many years ago, interest evaporated – at least in Western countries – because antibiotics proved to be more effective. As a result, treatment with phages is permitted here only in rare exceptions, whereas it has long been widely used in countries of the former Soviet Union.

The eight ETH students worked full-time on their project from July to October. "And beyond," says András Cook, 22, who, like Rechsteiner, was part of the ETH team in Boston. He laughs and adds: "I'll certainly remember all the nights we spent in the lab!"

The project is special in that, unlike other modules, it gives students a lot of freedom to take the initiative – starting with the topic, which they choose largely by themselves. In the spring, they met up weekly with professors and mentors who supervised the process, Cook explains: "At the beginning, everybody pursued their own idea. After that, we worked on the most promising suggestions in groups, until only one was left." Rechsteiner adds: "The topic of phage therapy fascinated us because it's relevant, not that much research has been done on it and we found an approach that was feasible."

MAKING DECISIONS FOR THEMSELVES

For the most part, the students organised themselves. They split themselves into three groups, each of which pursued a different path to reach the same goal. A fourth group was responsible for building the bioreactor. Supervisors and mentors helped and gave tips, but intervened only when necessary. "We got an empty lab and a budget. Then we had to decide for ourselves how to proceed," Cook says. And this was not limited to finding a topic and a methodology. They also had to raise the money themselves for materials and for their trip →

“Phage therapy is relevant, and not that much research has been done on it yet.”

Cheyenne Rechsteiner, biology student

Effective adversaries for antibiotic-resistant bacteria are to be identified in the bioreactor.

The bioreactor is ready
for transport to Boston.

"I've learned a lot more than I would have in an ordinary research project."

András Cook, biology student

to Boston. "We sent out a lot of letters," Rechsteiner says. "In the end, we managed to cover most of the costs of around 35,000 Swiss francs from donations."

LEARNING TO DEVELOP THEIR OWN IDEAS

Three professors run the project module: Sven Panke, Yaakov Benenson and Jörg Stelling. "This type of module is certainly unique," says Stelling, who has been supervising the project since 2005 and travels to Boston every year. "It is completely project-based."

Behind the idea of offering a competition as a module format is the conviction that students learn more when they can design a project by themselves from start to finish. Taking responsibility for their own work boosts their intrinsic motivation, Stelling says: "They learn to implement their own ideas." Another motivating factor is the narrow timeframe culminating in the presentation in Boston, where the students compete against other top-quality teams (e.g. Harvard, MIT, Stanford).

The job of the faculty members is to steer the process in the right direction, but to stand back whenever possible. "We prefer not to intervene explicitly," Stelling says. In his experience, students need support above all when generating ideas and when structuring the project work, so that they pursue interesting, new and realistic projects and then set the right priorities. In addition to the weekly meetings with the three professors, the students have access to mentors who coach and guide them. These mentors are doctoral students and have usually taken part in the competition in previous years. "They help with day-to-day problems, such as when experiments are proving tricky, or in discussions of the technical details," Stelling explains.

Naturally, the event also has specific learning goals, but these are not limited to bioengineering. Students are expected to make particular progress in project planning – after all, they are confronted with a range of tasks and problems that go beyond their work in the laboratory. "On top of that, the students must be capable of working in a team," Stelling says. "Sometimes that goes well and other times not so well. This year, it worked very well."

The students receive eight ECTS credits for the module. Compared to research projects that earn students roughly the same number of credits, there is a large investment in terms of work and time, the students emphasise. But they are enthusiastic all the same. "I've undoubtedly learned a lot more than I would have in a lecture module or an ordinary research project," Cook says. "For example, I can now construct a DNA model." Rechsteiner was also positive about her experience: "I like to push myself to the limits and work extra hard when I have the feeling I'm doing something worthwhile."

Last year's iGEM project is a good illustration of what can be done when you give motivated students a large degree of autonomy. By creating new binding proteins and thereby modifying the natural phages, they were able to compile a "phage library" containing around 10,000 variants. "The students went very far with their idea," says supervisor Stelling. "We're extremely satisfied. And we're discussing internally whether and in what form we could pursue the project further." It wouldn't be the first time that a former iGEM project has given the impetus for further research.

For the students, the five days in Boston from the end of October capped an extraordinary six months. In the end, the jury rewarded them for their intensive work with one of the 163 gold medals awarded. But their journey was not quite over yet. Together, they travelled onwards to New York. This time, however, they did not have the bioreactor in their luggage – it was a personal trip. A holiday with a random bunch of colleagues who scarcely knew each other six months before? "Spending all those days and nights in the lab together forged friendships," Cook says. •

(Re)discovering independence

Guest column

Digitalisation changes the way we live, work, communicate and obtain information. The accelerating cycles of technological change are creating new challenges for all of us. As a rule, when our graduates leave university, they have approximately 40 years of work ahead of them. Considering the rapid pace of change, this is a long time. It also means that, as teachers, we have a certain responsibility. For those of us at institutions of higher education, it is our duty to prepare students for the agile, rapidly changing world that we live and work in.

Apart from developing sound expertise, the key factor here – and, strictly speaking, this is nothing new – is to encourage the empowerment of the individual. Being able to manage change and uncertainty requires common sense, critical thinking, creativity and a willingness to take action. It's a matter of accepting responsibility for oneself and others – in other words, of developing an understanding of one's own role as a member of society.

WHAT IS SELF-COMPETENCE?

Given the developments described above, it is becoming increasingly important to have abilities that go beyond mere expertise, that enable the individual to become self-aware and shape their personal biography through lifelong learning. In addition to imparting intellectually demanding knowledge and the associated skills, the university is directly tasked with empowering its students to solve current and future challenges systematically and reflectively, but above all, independently. The goal, therefore, is to combine specialist expertise with personal skills.

A capable person has sound technical knowledge, relevant abilities, social skills in interacting with others, and self-competence as an individual.

So self-competence is more than just independence: it also includes responsibility, a willingness to help shape processes in a way that is self-directed; reflexivity, the ability to learn from experience and to think and act critically; and finally, the capacity to learn, which enables the individual to get a realistic idea of their own skills acquisition and continue to develop them systematically. However, this competence is rarely found in descriptions of our degree programmes and modules; where it does appear, it is unlikely to be structured in the curriculum.

This gap is surprising. After all, academic professionalism has invariably intended that university graduates emerge from their studies capable of making decisions and acting responsibly, freely and autonomously. It is not a question, therefore, of qualifying graduates for a changing labour market, but rather of turning them into mature, self-determined members of society. In other words, the objective is also to teach them values, standards and insight – thus giving them space for their personal development – in addition to sound expertise and scientific methodology.

PROFESSOR SÖNKE KNUTZEN
Head of the Institute of Technical Education and University Didactics, Hamburg University of Technology

Photo: Courtesy of Sönke Knutzen

BACK TO OUR ROOTS: RESEARCH-BASED LEARNING

But how can this be done? The image of mass universities is often coloured by packed auditoriums and an emphasis on classroom study formats. However, learning research has clearly shown that the ability to act effectively in future situations is not acquired through abstract knowledge alone. Instead, the skills necessary for effective action are achieved by tried-and-tested, carefully considered strategies of action. To put it simply: action itself is a prerequisite for learning how to act.

The concept of research-based learning works particularly well in encouraging knowledge-based empowerment as academic professionalism. This underlines the connection between research and teaching, dovetailing perfectly with how universities perceive themselves.

Research provides a reference framework within which to arrange learning processes. The goal is to introduce problem-based learning as a way of acquiring knowledge. Learners study research topics using established scientific methods, thereby becoming part of the scientific community. What's more, by engaging in research, students adopt a critical, constructive approach and thus also acquire a scientific self-perception that ties in with the above concept of "academic professionalism".

Students are gradually introduced to independent research. First, they are presented with current research findings, usually in lectures as part of the basic study programme. However, it may prove helpful for students if these lectures also include the process of knowledge acquisition. What research led to these findings?

These lectures are accompanied by methodology seminars and field trips to introduce students to scientific methods and research processes as soon as they start university. This gives them the opportunity to experience science, rather than knowledge, at first hand from the outset.

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This way, the students gradually discover more sophisticated levels until, as they reach the highest stage – the Bachelor's thesis – they attain the necessary self-competence to complete an entire research process.

NEW ROLES

The challenge for universities lies in ensuring that curricula and teaching/learning formats include sufficient scope to pave the way for self-organised learning and working. Therefore, to some extent, university teaching sees its role as that of guiding students as they acquire skills independently. This is where the shift from teaching to learning comes in. Learning is a holistic, self-organised acquisition and development process, with students being supported and guided by teachers and institutes alike.

In other words, research-based learning is changing the roles of teachers and learners in equal measure: teachers are no longer merely communicators of knowledge, but also tasked with providing advice and support. Students are no longer recipients of processed knowledge, but largely determine their own learning process.

SHAPING THE FUTURE

The world is changing at a faster pace than we are accustomed to. Digitalisation and globalisation are the drivers of this development; its first visible consequences are global warming and changes in society. What our society needs is creative thinkers who can develop ideas and implement them. We need visionaries who want to get involved and help shape the future. By introducing innovative teaching, ETH Zurich has taken steps to help its students acquire the self-competence to apply a knowledge-based approach to solving problems. Research-based learning has the potential to promote the strategies and ways of thinking that are required in an agile world. This form of learning represents what universities stand for: the dovetailing of research and teaching with a view to shaping the future. •

INNOVEDUM – THE FUND FOR INNOVATIONS IN TEACHING

Through the Innovedum fund, the Rector supports the implementation of new ideas in teaching. Its primary aim is to continually adapt the learning environment to students' emerging needs so that they become critical thinkers who are equipped to shape the future. Innovedum supported the following projects:

SUSTAINABLE CONSTRUCTION

Analysing building concepts during the design process

The effect that buildings have on the environment can be calculated using what are known as life-cycle analyses, which take construction, operation, demolition and recycling into account. At the moment, however, such analyses are performed only post-construction. "But by that point, it's too late to make improvements," says Guillaume Habert, Professor of Sustainable Construction in the Department of Civil, Environmental and Geomatic Engineering at ETH Zurich.

This makes it important to conduct life-cycle analyses during the planning stage of a building. That is exactly what students learn about on the project-based Design-Integrated Life Cycle Assessment course, which ETH has offered since the beginning of 2019 for all departments involved in the integrated building systems Master's degree programme. What makes this course so special is that students carry out life-cycle analyses on building concepts that a design class in the architecture department are working on at the same time. To do this, they use various modules of a software tool called Bombyx, which was developed by Habert's group and is integrated into the 3D design software that the architecture students work with. This way, the results of the life-cycle analysis can be incorporated directly into the building designs.

"In the course of their project work, the students learn how to deal with other disciplines as well," Habert says – an effect supported by their exposure to the lecturers' various fields of expertise, which include life-cycle analyses, organic construction materials and computer science. The unusual format of the final examination did justice to all these different perspectives: the students broke into small groups to discuss their work with each lecturer in turn, giving each examinee several opportunities to demonstrate their knowledge and to shine in their strongest subject area. •

MASTER'S IN QUANTUM ENGINEERING

Studying what does not yet exist

When students decide to do a Master's in quantum engineering, they enter brand new territory. "Quantum engineering isn't something that exists today, so we have to invent it," says physics professor Lukas Novotny. This new degree programme will enter its second year in autumn 2020 and will be offered by the Department of Information Technology and Electrical Engineering and the Department of Physics. As part of the programme, students are asked to participate in shaping how the course evolves. Other, compulsory elements include independent project work and research for an internship, a term paper and a Master's thesis. •

LEARN ONLINE, DISCUSS IT AT UNI

Maths for 650 students

How do you design a lecture for 650 students so that everyone gets the most out of it? That is the question that mathematics lecturer Andreas Steiger asks himself when he plans his two-part analysis course. This year-long foundation course is aimed at first-year students from the materials science and mechanical engineering degree programmes.

His solution? A combination of interactive elements, apps and videos. Using an online platform, students can experiment with mathematical functions on their own by changing parameters and viewing 3D visualisations to see behind the numbers. As part of the exercises, they solve online quizzes that provide immediate feedback on what they did right and where they went wrong.

When students join Steiger's analysis course straight out of upper secondary school, their prior knowledge of the subject matter varies greatly. To quickly get them all up to the same speed, he uses the "flipped classroom" method of teaching for two weeks in the autumn semester. The students learn the teaching material at home, with the time in lectures then used to focus on exercises that can be adapted to suit the levels of the individual students. The students also support each other through peer teaching. •

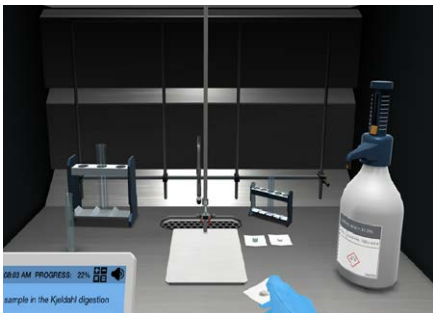
FOOD SCIENCE

Virtual experiments

Practical lab courses are a key component of food science studies at ETH. They require students to learn certain basics such as lab safety, choosing the right containers and equipment, waste management and writing reports. Learning these basics takes a lot of time – time that could otherwise be spent on the experiments themselves.

To change this, Laura Nyström, Professor of Food Biochemistry, joined with Melanie Erzinger and other colleagues to introduce new learning methods. One of these is a virtual laboratory: in a simulation similar to a computer game, students can move around in a lab environment, weighing substances and mixing them together. The programme presents background information and poses theory questions. In this way, students learn lab processes in the safe confines of the simulator. "This method also lets us offer additional experiments that would be too dangerous or too time-consuming in a real lab," Erzinger says.

Furthermore, in short videos the researchers can explain the basics of lab work and of individual experiments. The students follow the "flipped classroom" concept and use the simulation to prepare for classroom sessions, which leaves them more time for sharing and discussions during lab work. •



Fostering the reinvention of education

Since the Innovedum fund was first established in 2004, it has financed almost 200 projects. Here is an overview of key Innovedum facts and figures.

Milestones

2005
First degree programme initiative

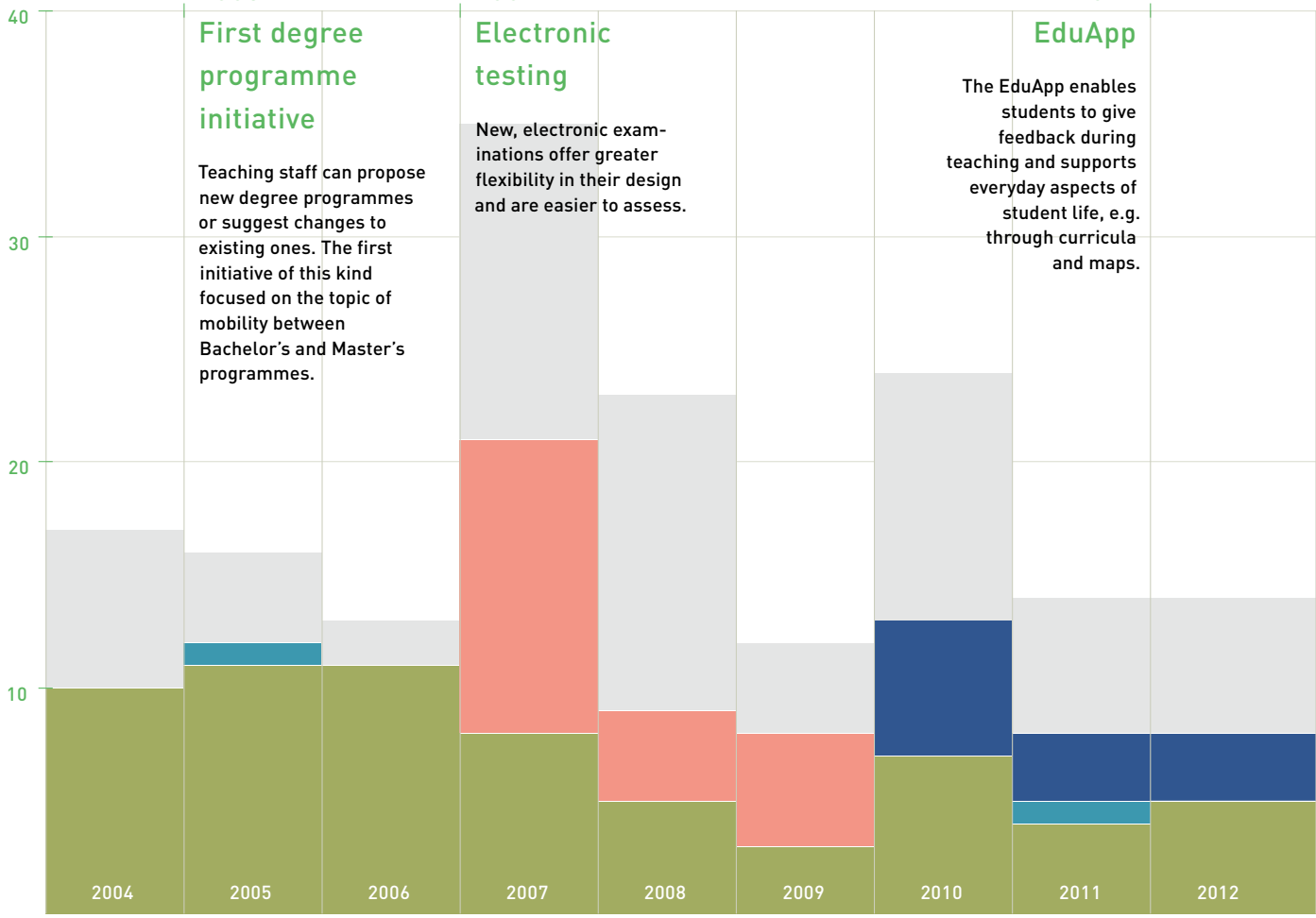
Teaching staff can propose new degree programmes or suggest changes to existing ones. The first initiative of this kind focused on the topic of mobility between Bachelor's and Master's programmes.

2007
Electronic testing

New, electronic examinations offer greater flexibility in their design and are easier to assess.

2012
EduApp

The EduApp enables students to give feedback during teaching and supports everyday aspects of student life, e.g. through curricula and maps.



197

projects funded since 2004

41

ongoing projects

This fund provides 2 million Swiss francs annually to support initiatives that develop education further at ETH.

Innovation + Education = Innovedum

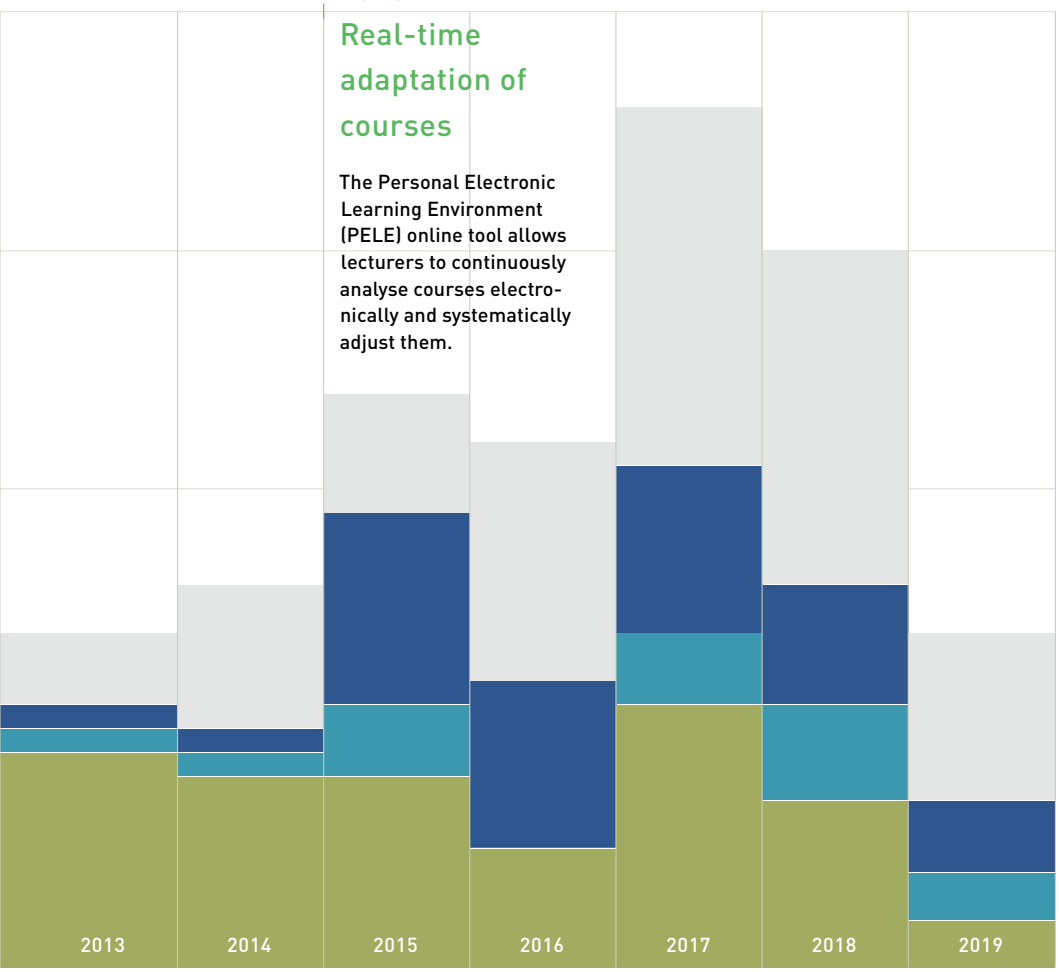
ETH has been promoting innovation in teaching for 20 years. It began these activities in 2000 as part of a strategic initiative called ETH World; from 2004, the main instrument was the Fonds Filep, which was rebranded as Innovedum in 2010.

16 revised and new degree programmes have been supported since 2004. One of the latest additions is the Master's in quantum engineering (→ page 22).

2015

Real-time adaptation of courses

The Personal Electronic Learning Environment (PELE) online tool allows lecturers to continuously analyse courses electronically and systematically adjust them.

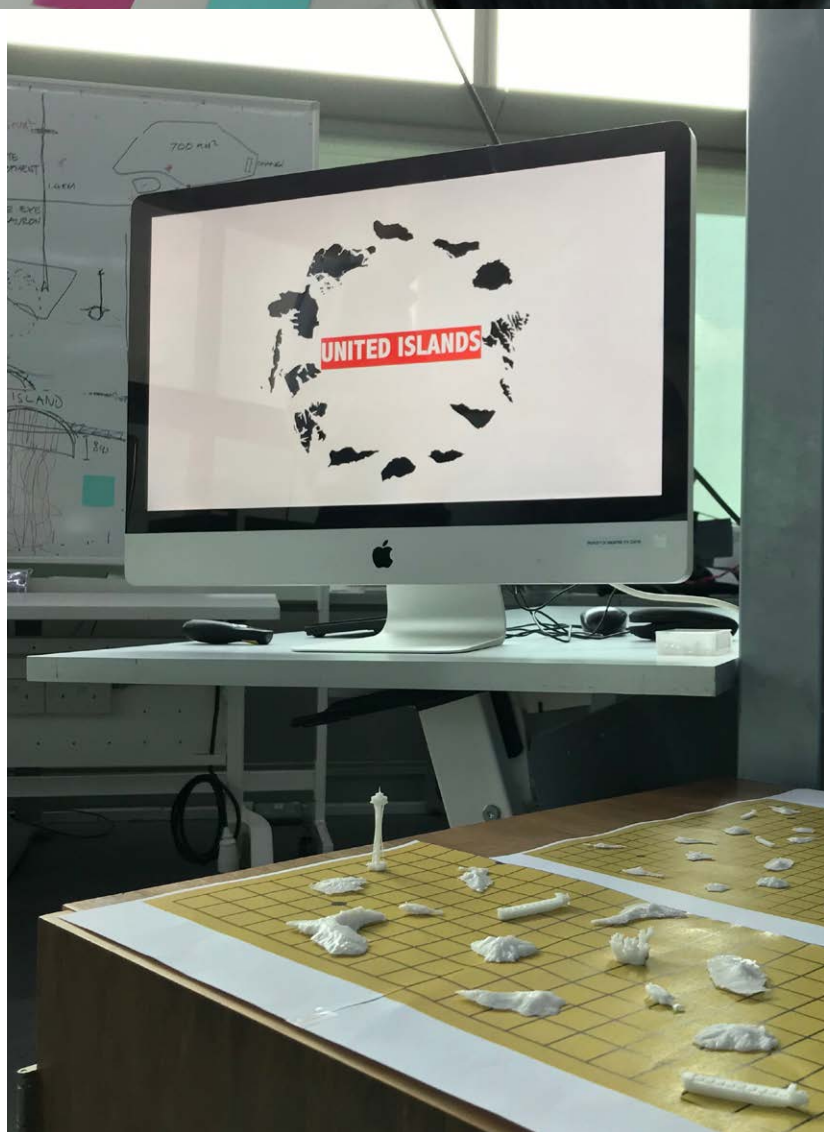


Number of projects submitted

- **Rejected projects**
- **Teaching projects:** Innovative projects that aim to improve the quality of courses at ETH Zurich
- **Small projects:** Projects with simple approval procedures and a budget of less than 30,000 Swiss francs
- **Focal point projects:** Projects for promoting certain topics (e.g. interactive lectures)
- **Degree programme initiatives:** Through such initiatives, the content of existing degree programmes can be adapted or entirely new ones developed

More information: www.ethz.ch/innovedum

Above: Professor Marc Angélil (second from left) discusses potential solutions with Michail Karakikes's (third from right) group. Below: Mini-models of islands illustrate the idea.



INTERDISCIPLINARY PROJECT WEEKS

Working with students from very different subject areas and cultures to design and implement a project. This is the main idea behind ETH Zurich's interdepartmental project weeks – which can sometimes last for almost a whole month.

Get out of your comfort zone!

The first ETH Singapore Month took place last year. Students from seven different universities travelled to Singapore to embark on an interdisciplinary cultural adventure together. Their challenge: develop ideas for (nearly) unsolvable global problems.

By Claudia Hoffmann

Take students out of their familiar surroundings and team them up with students from other disciplines to stimulate new ways of thinking: that's the concept behind the ETH Singapore Month, a workshop for Master's students in all subjects, which was held for the first time in 2019. "It's a major challenge for the students," says Marc Angélil, Professor Emeritus of Architecture at ETH, who led the workshop together with Aurel von Richthofen from the Singapore–ETH Centre. That is because up to that point, most of the students had barely glanced outside the scope of their own area of study. Angélil believes that "instruction at ETH is still too 'monodisciplinary'." When students are working on their Bachelor's degree, he continues, it is indeed important that they focus on their own subject so that they build a solid foundation, but that has to change at the Master's degree level. "After all, we know now that difficult issues are best resolved in mixed, multidisciplinary groups," Angélil says.

This is precisely what happens during the ETH Singapore Month, an initiative established by ETH Rector Sarah Springman together with Gerhard Schmitt, Director of the Singapore–ETH Centre. The format is similar to that of ETH Week, which began in 2015: once a year, a group of some 200 students →

representing every ETH academic department work together to develop solutions for society's problems.

URBANISATION UP CLOSE AND PERSONAL

The first ETH Singapore Month lasted three and a half weeks and focused on The Future of Urban Society. Singapore was chosen as the location for a couple of reasons. One was the expertise of the Singapore–ETH Centre, an interdisciplinary research institute founded in 2010 together with Singapore's National Research Foundation. Another was that the centre offers the necessary infrastructure and is well connected with the Singapore authorities and decision-makers. "Besides, Singapore is the ideal place to research the future of urban societies," Angélil says.

That's because the island city-state is a prime example of what will become an issue worldwide: more and more people are living in less and less space – Singapore's population density per square kilometre is about 40 times that of Switzerland. The city has no hinterland and hence no agriculture. Handling the importing of food, the water and power supply, city and traffic planning, and the effects of climate change all pose serious challenges.

ETH Singapore Month was split into two parts: an introductory week and a two-and-a-half-week workshop. During the introductory week, the 20 ETH students first immersed themselves in the local culture and got to know their new surroundings. "Most of us had never been to Singapore before," says Michail Karakikes. Originally from Greece, he is now studying for his Master's degree in mechanical engineering at ETH Zurich. The opportunity to experience a new culture was an important factor in his decision to apply for the month in Singapore. "Unfamiliar surroundings inspire new ideas," Karakikes says. Studded with skyscrapers, the city's skyline alone was enough to impress him. However, the students didn't just visit the architectural marvels, they were also able to look behind the scenes; for example, they met with representatives of Singapore's urban planning authority, who reported on plans to expand the city. With Singapore bursting at the seams, the city wants to reclaim coastal areas by adding material to the ocean. Karakikes reports, "It was exciting to learn about the challenges they face here and what approaches they are taking to address them."

"Singapore is the ideal place to research the future of urban societies."

Professor Marc Angélil

TACKLING PROBLEMS AS A TEAM

His impressions from the introductory week continued to inspire him in the subsequent workshop. Attending this workshop were a total of 48 students from 7 different universities, including the Massachusetts Institute of Technology (MIT), the University of Cambridge, the Technical University of Munich and 3 Singapore universities. Every morning, the students heard talks from administrative and research experts on a wide range of topics, including actions Singapore is taking to combat climate change (such as reducing CO_2), mobility systems of the future (self-driving cars, for example), waste management and the relationship between politics and science.

The actual workshop sessions took place in the afternoon, with students split into groups of six. Each group contained a mix of disciplines, universities and cultural backgrounds. All the groups were asked to select one of the United Nations' 17 Sustainable Development Goals for 2030, which include eradicating hunger and poverty, establishing gender equality, making cities sustainable and protecting biological diversity. All are complex and, as yet unsolved challenges – and some of them propose to tackle problems that are not even clearly defined. "Our plan was to deliberately confront the students with this uncertainty and push them out of their comfort zone," Angélil says.

Karakikes's group chose the topic "life below water", which aims at protecting the oceans: How can humans combat overfishing, plastic waste and coral bleaching? These are problems that are of special concern to island nations like Singapore. Right from day one, the groups were expected to brainstorm fresh ideas and discuss them. "That was the toughest challenge for me," Karakikes says. Not only did the group members come from different areas of study, such as the social sciences, urban planning or engineering, they also hailed from different cultures, such as India, Indonesia or China. "At the start, you don't know what the others will perceive as polite or impolite, and you first have to find a common language," he continues. And yet as it turned out, the differences weren't so big after all.

THE JOURNEY IS THE DESTINATION

Another aspect of the workshop was how to apply the principle of design thinking: first, you map a situation in its entirety; only then do you define the problem you want to solve, and finally, generate as many ideas as possible. "We often tend to focus on the end product," Angélil says. In his view, however, the process is just as important – in other words, how the students lay out the path towards their goal and how they resolve conflicts within the group. Every group receives support from a mentor. For example, Angélil, who mentored Karakikes's group, set clear time limits for the individual steps of the process. "That was very helpful, because otherwise our discussions would have gone on forever!" Karakikes observes.

The ideas that emerge during the creative process do not necessarily need to be feasible; they can be completely off the wall. For example, one group suggested using artificial clouds to provide more equitable access to water around the world. One idea in Karakikes's group was to breed plankton in vast floating bubbles to absorb CO_2 from their environment and create biofuels. Another was to collect plastic waste from the ocean and use it to build islands. Crazy ideas like this are an important step along the journey, Angélil explains: "You need to aim for utopias to arrive at really good, realistic ideas."

Some proposals are already being tested, such as using ocean currents to generate power or storing CO_2 on uninhabited islands.

At the end of the three and a half weeks, the groups each prepared an exhibit and presented their ideas to local stakeholders. "I was pleasantly surprised to see how boldly and confidently the students spoke in front of an audience," Angélil says.

Students and organisers alike were very pleased with the first edition of the ETH Singapore Month. For Michail Karakikes, the group work was an especially valuable experience: "I've learned to appreciate other ways of looking at the world, even if they are completely different from my own." Angélil also describes the month in positive terms: "For us, it was a chance to test out how we might organise such interdisciplinary workshops outside ETH in future." •

SPACE FOR SELF-INITIATIVE

Students who want to work on private projects in their free time can make use of the Student Project House. Those who have the potential to become entrepreneurs may be eligible for a stipend, and the Innovation & Entrepreneurship Lab (ieLab) can also connect them with seasoned entrepreneurs willing to lend them support.

Researching a sustainable superfood

Pioneer Fellows Cyrill Hess and Melanie Binggeli want to market duckweed as a healthy food that's good for the environment. In founding their start-up, LemnaPro, they received key support from Professor Achim Walter, the Innovation & Entrepreneurship Lab (ieLab) and the Student Project House.

By Samuel Schlaefli
Photographs: Judith Stadler und André Uster

→

Cyrill Hess and Melanie Binggeli with a sample of *Wolffia*.

Plants

with tiny light green leaves, a taste reminiscent of bean sprouts and a pleasantly grainy texture: Wolffia, one of five genera commonly known as duckweed or water lentils. It is also the most easily digestible, as Cyrill Hess explains at an impromptu tasting in a basement-level environmental chamber at ETH Zurich's Department of Environmental Systems Science. Just moments before, he had used a sieve to skim the *Wolffia* off the water in a wooden basin in front of the tasters. The grass-green carpet floats atop an aqueous nutrient solution that is continually cleaned by a pump. Scientists can precisely control the chamber's temperature, humidity and lighting conditions. Hess started cultivating the *Wolffia* two weeks ago on a water surface measuring about five square metres. On a good day, he skims off 1.5 kilogrammes of this "green caviar" – that's what he calls the product that his start-up, LemnaPro, is working on.

FAST GROWING AND HEALTHY TOO

Hess, who studied environmental sciences at ETH Zurich, conducted research with duckweed while working on his Master's thesis and came to recognise its potential: "No flowering plant reproduces faster," he explains. Under favourable conditions in the wild, it can cover ponds and small lakes in just a few days. Hess continues: "It also contains large amounts of high-quality plant proteins, lots of fibre, valuable unsaturated fatty acids and few carbohydrates." An obvious choice to be deemed a superfood, duckweed has long been prized in Asian cuisines but is largely unknown in Europe.

He discovered his enthusiasm for alternative and sustainable foods in Achim Walter's lectures on alternative crops. Walter, Professor of Crop Science at ETH, wants to help build a sustainable world food system through research, new technologies and alternative crops. "Walter is keenly interested in how to put agricultural research into practice," Hess explains. "When I told him about my idea two years ago, he arranged with the HR department for me to be a guest researcher, so I could use the lab and environmental chambers for refining my concept."

At the same time, Walter also introduced Hess to his former student Melanie Binggeli. During her studies, she was active in the ETH Entrepreneur Club and other start-up networks. "Cyrill immediately won me over with his product and his personality," she says. Binggeli wrote her Bachelor's thesis on soy and her Master's thesis on insects, so she already had some experience with alternative sources of protein. "The UN Food and Agriculture Organization says that by 2050, we will have to increase food production by 70 percent. To do that, we urgently need new approaches," she says, continuing: "What really fascinates me about research is putting new knowledge into practice, so we can do something positive for people and for the environment."

A PLACE FOR PROTOTYPING AND VISION

One key part of the progression from the initial idea to the first product samples was the Student Project House. "The infrastructure of the Makerspace is incredible!" Binggeli recalls. "With CNC mills, 3D printers and many other tools, we had everything here that we needed to develop prototypes further as quickly as possible." The team is now on its third hydroponic system designed for *Wolffia*. What started out as a plastic crate and an aquarium water pump has transformed into a sophisticated wooden basin with specific current properties for optimum *Wolffia* growth. In addition, the Student Project House provided the pair with an experienced mentor: since March 2019, Hess and Binggeli have been meeting regularly with Lucie Rejman, who is in charge of projects in food and agricultural sciences. "The Student Project House is the ideal counterpart to lectures," Rejman says. "Here, students can apply their knowledge in practice, learning how to work in teams and to jointly develop solutions." Rejman herself earned a doctorate in food process engineering at ETH. Afterwards, she founded a start-up called ZüriChips, which strives to reduce food waste. Rejman is no stranger to the problems of young projects. "I share my own experiences, help in building up a network, provide encouragement in difficult patches and show how important it is to test out ideas at an early stage," she says. In the case of LemnaPro, she helped them flesh out a business vision, a set of rules for collaborating together, and principles for further developing the project.

APPLYING FOR PERMISSION, DEVELOPING THE MARKET

However, there are still several challenges for the start-up to overcome before consumers will find *Wolffia* on the supermarket shelves. For one thing, the production process in the environmental chamber is complicated. It needs to be optimised to prevent →

“There are always dozens of problems that would be reason enough to leave the idea alone.”

Cyrill Hess

Wolffia duckweed contains plenty of high-quality proteins, fibre and unsaturated fatty acids.

other organisms spreading and posing a threat to the duckweed or to people. "Plant disease is responsible for the failure of most previous ventures that have attempted to cultivate duckweed. The larger the volume, the more difficult it is to minimise production costs while maintaining hygienic conditions," Hess says.

Another challenge is of a legal nature: Hess and Binggeli must seek approval from the European Union for a novel food before *Wolffia* can even be sold in the EU and in Switzerland as a foodstuff in the first place. This approval process requires dozens of analyses, and Hess estimates that the EU dossier will cost half a million Swiss francs. "After obtaining approval, we then need to create a market for our product," he explains. Consumers first have to get to know *Wolffia* – for example, it is perfectly suited for smoothies or as a salad.

Despite the remaining challenges and unknowns, the two young entrepreneurs are focused on their goal. "There are always dozens of problems you have to solve, and they would be reason enough to leave the idea alone," Hess says. "But we've learned to listen to our intuition, stay motivated and not let ourselves be intimidated."

Hess and Binggeli received ETH Zurich Pioneer Fellowships in September. The fellowship supports ETH researchers as they work to develop products based on their scientific work. They receive access to laboratories and office space, and gain a year to work on their idea without financial stress. The harvest from the environmental chamber in the basement of the Department of Environmental Systems Science will soon be sent out for testing to an investor in the food industry – one who apparently can't wait to try this "green caviar". •

Student Project House

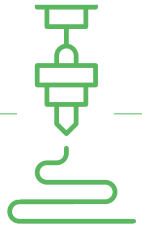
Develop ideas, reject them, fail with them, realise them!

1,500

users since its opening

16

from 16 different disciplines



28

machines in the
makerspace: 3D printers,
mills, saws

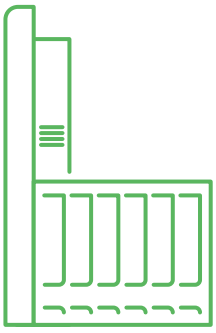
37

projects, including:

Yasai: Vertical farms
Tethys: Underwater robots
4mosst: Self-growing paint made of moss
LemnaPro: Duckweed, the superfood

2021

will see the Student
Project House's
new main location
officially open



5

floors in the renovated
district heating plant near
the Main Building

+ 1,140 m²

At the Student Project House, failure is allowed. Here, students are encouraged to try out their ideas and projects, freed from schedules and regardless of their courses of study or credit requirements. They receive project support from experienced mentors and have access to a workshop equipped with 3D printers and mills, a coworking space, and rooms for workshops and product pitches.

Students developing a business idea.

BIO-ENTREPRENEURSHIP AND TRANSLATIONAL MEDICINE

A pitch instead of an exam

In their first few semesters, biology students don't usually get too hands-on with their future careers. Professor Ernst Hafen believes that a practice-based course is just what these students need, which is why he launched the Translational Medicine and Bio-Entrepreneurship block course three years ago. "This course is not about basic biological research, for once, but specifically about its application," Hafen says.

The key aim is for students to develop a business idea within three and a half weeks. At the end of the course, instead of taking an examination or writing a final paper, they present their start-up idea to a jury that then evaluates their pitch. In one example from recent years, students developed the idea of using the Valora bees' gut bacteria to stop bee mortality. Another group's project that still delights Hafen to this day involved producing biochar from organic waste and using it in road and concrete construction as a way to sequester CO_2 and ensure that it does not re-enter the atmosphere.

The course is held at the Bio-Technopark Schlieren-Zurich, of which Hafen is president. He invites some of the founders of the start-ups based there to be guest lecturers. Last autumn, for example, the CEO of ETH Zurich spin-off Neurimmune talked to the students about the ups and downs in the development of a novel Alzheimer's drug for US biotech giant Biogen – a project worth billions. Representatives of pharmaceutical companies are also frequent guests. For example, a high-ranking Roche representative spent a day with the students to work through the launch process for a cancer drug, covering all the steps from development to the approval procedure.

Besides the development of a business idea and the input from the entrepreneurs, a book club rounds off the course programme. In a roundtable, students discuss a controversial book about start-ups. Hafen's hands-on course has clearly struck a chord: it is limited to 30 participants and is regularly oversubscribed. •

Photographs provided (2)

Develop your own ideas for marketability

"No bla, just do – turn your idea into a start-up!" David Hengartner's website takes a brash tone when asking students to explain their motivation for taking part in the Lean Start-up Academy. Every year, the course enables 30 students to advance their ideas using a structured innovation process that sees them develop a tangible prototype within one semester. Hengartner heads up an innovation programme at Swisscom and is an external lecturer at ETH.

He has been offering this course to Master's or doctoral students from various departments for three years now. Students interested in taking the course apply online and Hengartner selects, who he considers the most motivated to participate. "The course is very demanding in terms of commitment and energy," Hengartner says. He tries to make the class as diverse as possible so that is it made up of people from a wide range of different disciplines.

"We work with models to show how innovation process should be designed, but the course also has a very strong practical focus," Hengartner explains. Not all students come with their own idea. Instead, at the start, the "champions" pitch their ideas and try to win over and recruit enough members for their project team, and the participants arrange themselves into groups accordingly. The start-up ideas are varied and range from e-learning concepts for piano students to a system for monitoring the noise levels premature babies are exposed to in intensive care units.

The teams refine their concept and develop prototypes with a project budget of 1,000 Swiss francs. In seven evening sessions over a semester. At the end, they present the idea and their work to a jury made up of experts from Swisscom, the ETH Chair of Entrepreneurship and several start-up support organisations such as VentureKick. "We put students in contact with the incubators and accelerators in the start-up ecosystem. After all, our goal is for the groups to continue their projects after the course has come to an end," Hengartner says. •

A teaching session at the Lean Start-up Academy

Navigating unknown territories

By MICHELA PUDDU,
founder and CEO of Haelixa,
an ETH spin-off company

Eight years ago, I moved to Zurich for a six-month stay, and without knowing exactly what to do or expect after my Master's in materials science and technology. I found a unique environment where international talent and innovation thrive, which made me want to stay longer. Today I am the founder and CEO of my own company, Haelixa. This is my story: an Italian student who became an entrepreneur.

RESEARCH THAT MATTERS

I believe that doing good scientific research is one of the best ways to contribute to concrete solutions to socio-environmental problems. But doing research that matters and that promises rapid impact often clashes with the research cycle span. Quality takes time and money. At ETH, I found an environment that provides the resources and the ecosystem to work efficiently and quickly deliver good quality. This led me to apply for a doctorate in chemical engineering at ETH.

As a doctoral student, I had the chance to propose and develop projects independently, yet with trusted supervision. My research on DNA-based tracers resulted into several high impact scientific articles and a patent. I worked in teams with other doctoral students, including Gediminas Mikutis, who later became my co-founder. Collaboration across departments and with industry is also encouraged at ETH, which creates highly qualified research teams solving real-life challenges.

I also took the opportunity to develop a new set of skills transferable to non-academic contexts, such as analysis and problem solving, teaching, project management, writing patents, working effectively under pressure, organising and communicating ideas effectively in written formats, and oral presentations. Moreover, academics at ETH can easily interact with one another and with industry, which allowed me to build a solid network.

By the end of my doctorate, I had received positive responses from both the public and private sectors that the technology I had co-invented with Gediminas Mikutis and other researchers could change the way products are traced and supply chains managed. Being confident enough to believe that I could catalyse this transition towards a transparent consumer goods industry, I swapped my lab coat for a business suit and decide to start a company. I thought it was the most direct and effective way to have an impact.

THE GAP: BUSINESS EXPERIENCE

However, like many other researchers, I excelled in technical expertise but did not have the needed experience to launch and grow a business. To fill this gap, I applied for the Pioneer Fellowship – and succeeded. The joint programme by ETH Zurich and the ETH Zurich Foundation supports individuals intending to develop an innovative product or service based

Photograph: Courtesy of Michela Puddu

on ETH research independently. Successful Pioneer Fellows applicants receive 150,000 Swiss francs and have access to an exclusive community of peers, mentors, advisors and proven entrepreneurs.

ALL IN – FOR THE UNKNOWN

Gediminas and I decided to found our company, Haelixa Ltd, shortly after I was granted the fellowship. We already had our first client willing to pay for our on-development products and services. I invested all of my savings into Haelixa, being totally unsure of what specifically my entrepreneurial journey would involve! Imagine that you know exactly where you want to go, but you have no idea how to get there.

I have always been naturally driven by a very strong personal commitment and discipline, and I am willing to take on responsibilities and risks and challenge the status quo. In a way, I think that if I had known beforehand what I was going to be up against, I would not have started my own business – I did it because I was free of worries and full of energy. Some people believe they need to have a deep knowledge of something before they can begin. But most things can be learned, and challenges can be faced when they materialise.

I have pitched Haelixa to different crowds and panels of industry experts or investors. The ETH reputation gave our spin-off great visibility, even outside the academic environment. I have used the credibility built to date to access funding outside of ETH and raised substantial equity-free funding that allowed us to finance Haelixa until we closed our first financing round.

ALONE

Finally, despite the fact that you get to meet so many people and even receive help from some of them, entrepreneurship can be a lonely business: responsibility lies with you, and you find yourself alone navigating unknown territories. Especially in the first several years, you will struggle with difficulties that you did not see coming: technical and legal hurdles, delays, projects not developing as planned. You need to make sacrifices, be ready to spend money you have not budgeted, jump on a train at the last minute and be away for a few days, plan and execute big projects within weeks, hire quickly when you suddenly cannot manage the workload. And when things go wrong, you need to be resilient, deal with the emotional inner monsters that accompany your start-up journey, and move on.

In order to maintain that resilience, both mental and physical, I do lots of sports and encourage all my team members to do the same. A couple of years ago, I started doing triathlons and yoga. But mostly, I run – and I have been running since I was a kid. Running fuels my journey. The morning that we incorporated Haelixa, I ran. The day that we did our first hire, I ran. The afternoon that we closed our first investment round, I ran. And ran and ran to get the courage, get rid of my nerves, and give the right meaning to each step I take.

INSPIRE OTHERS

Maybe it's this one aspect of entrepreneurship that makes it so attractive to me: it shares so many commonalities with sports. Both require passion, discipline, self-confidence and the determination to overcome obstacles, tolerate fear and develop the ability to step outside the comfort zone. Both require planning strategically and accepting failure. Both can have a good impact on society in many different ways and create role models that positively inspire others. I am committed to inspiring future leaders, particularly women, to have an impact, and to contribute to the achievement of the Sustainable Development Goals of the United Nations. •

Haelixa wants to contribute to a more transparent consumer good industry by offering an easy-to-use technology to create proof of product origin and integrity along the supply chain of goods such as textiles or precious minerals. Transparency acts as precondition for the control of social and environmental standards at each node of the supply chain.

ETH Zurich has plenty more new ideas and projects for the classroom in the pipeline. Those outlined below are ready for launch or started just a short while ago.

PRISMA DEGREE PROGRAMME INITIATIVE

Interdisciplinary projects for everyone

"While ETH already has a broad interdisciplinary offering, it tends to be an add-on to the degree coursework," says Medea Fux, a Master's student in interdisciplinary sciences and former Vice President of the Association of Students at ETH (VSETH). This has the effect of barring students who work a lot alongside their studies or who simply need more time for studying. In response, VSETH launched the PRISMA project (originally known as the Revolution of STEM Education, or ROSE for short), with the aim of more firmly embedding cross-disciplinary teaching and the learning of social and personal skills in the ETH curriculum. In the future, groups of five to six participants from various degree programmes will work together on a project for one semester. The main goals include improving teamwork skills, applying the design thinking method, learning decision-making skills, carrying out critical self-reflection, and experiencing interdisciplinary collaboration. Participants will receive support from a pool of trained Master's students, who in exchange have the opportunity to gain real-life leadership experience.

PRISMA is supported by the Rector through the Innovedum fund. January 2020 saw the launch of a 21-month pilot phase, based at the Department of Management, Technology, and Economics (D-MTEC). Thereafter, new partner departments will be added on an ongoing basis. An experienced project manager and two students are splitting PM duties equal to a 1.6 full-time equivalent post. Spring Semester 2020 saw coach training carried out and evaluation criteria for the new offering defined. Fux hopes that the new teaching format will progress far enough by the end of Spring Semester 2021 that it can be opened up to all ETH students in the medium term. •

SUMMER SCHOOL IN GHANA

On-site learning

ETH Sustainability and ETH for Development (ETH4D) plan to join forces with the Kwame Nkrumah University of Science & Technology (KNUST) to hold a summer school programme in Ghana. It will focus on "Rethinking Waste – Sustainable Solid Waste Management", with ETH students and KNUST students meeting in Kumasi to develop new ideas for one of the most urgent problems of our time. The students will get to grips with the issue of waste management through a series of lectures, excursions and workshops with experts from science, industry and NGOs. Afterwards they will apply design thinking to a practical problem in Ghana. During this process, the students learn to take a structured approach to developing solutions for complex sustainability challenges as they work in interdisciplinary and intercultural teams. •

COURSES, CASE STUDIES, VIDEOS

Web platform for ethical issues

ETH Zurich's ETHics Resource Platform fosters the development of ethics skills at the university. To this end, the Health Ethics & Policy Lab curates a web platform featuring videos, podcasts, international codes of conduct, ETH guidelines, case studies, articles and interviews. Interested parties can also consult an index of courses on ethics subjects. A search function lets them look up courses by topic: for example, how to manage personal data on the internet, or patient data for personalised medicine or organ donation. ETH students and staff are to be encouraged to critically review ethical issues in a research setting. The platform was initiated by Effy Vayena, Professor of Bioethics in the Department of Health Sciences and Technology, with support from Sarah Springman, the Rector of ETH Zurich. •

Refuse collector at an open-air rubbish dump

FUTURE LEARNING INITIATIVE

Achieving a better understanding of learning processes

With the Future Learning Initiative (FLI), ETH Zurich is establishing one of the world's leading research centres for teaching and learning. This move should also expand ETH's reputation as a leading educational institution. The FLI consists of 23 professors from 9 departments. Their interdisciplinary cooperation should frame new questions and issues that they can then tackle together. The overall goal is to achieve a better understanding of learning processes as multifaceted neural, cognitive, embodied, social and cultural phenomena. Currently, the FLI is focused on mixed reality technologies for training in medicine and bioengineering, novel learning spaces, ethics in learning and the use of gaming in teaching. The initiative is an ETH+ project, which the Executive Board uses to drive the development of new strategic topics and encourage interdepartmental cooperation. •

Photograph: Adobe Stock

Support education for the future at ETH Zurich

Various teaching projects have been made possible by dedicated donors like ETH alumnus Adrian Weiss or foundations like the Avina Stiftung and the Dätwyler Stiftung. Below we highlight several successful examples.

The examples on this page were made possible by the Rector's Impulse Fund endowed by Adrian Weiss. With support from the Fund, educators have the opportunity to adopt new ideas and pioneering approaches and further develop them for a maximum of one year. Successful projects are then permanently integrated into the curriculum where possible.

ARCHITECTURE

Reshaping the design course

The design course for architecture students was somewhat different from usual. In the Spring Semester 2019, Professor Christian Kerez's team of assistants – Joni Kacani, Hermes Killer, Gianna Ledermann and Federico Rossi – together with assistants from the Department of Humanities, Social and Political Sciences had the opportunity to design the course themselves during his sabbatical. They challenged students to identify recurring phenomena in contemporary architecture, place these in a wider social, economic and cultural context, and then reflect on their findings in a paper. The course also introduced students to literature research in the humanities and the fundamentals of academic writing. Such experiences not only make it easier for students to prepare for a possible academic career, but also teach skills for day-to-day work as an architect – work characterised by a constant balancing of social, political, legal, economic and design concerns. •

ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY

Independent learning through videos

Lectures are often highly theoretical in nature and disseminate information at a fast pace. Students have barely any time to comprehend the material presented thoroughly and to consider how the theories might be applied in practice. One project in the Bachelor's programme in electrical engineering and information technology aims to help: students Lioba Heimbach and Markus Niese are spearheading the production of short videos that visually explain the core concepts of mandatory courses and provide the ideal complement to the lectures. •

"I've been reaping the rewards of my ETH education my whole life. Now I want to give something back to the university."

Adrian Weiss,
ETH Zurich patron

A lecture during ETH Week on the technology underpinning the Gotthard Base Tunnel

ETH WEEK

Lateral thinking spurs innovation

Deep diving into a complex problem, organising into teams and developing novel and robust solutions under time pressure: with these activities, the annual ETH Week promotes interdisciplinary collaboration and out-of-the-box thinking as it confronts students with society's greatest challenges. ETH Week is possible in part due to the generous support of the Avina Stiftung and the Dätwyler Stiftung.

"ETH Week forces you to get out of your comfort zone and open yourself up to new ways of thinking."

Sebastián Guerrero Soriano,
Master's student in physics

YOUR COMMITMENT MAKES GREAT THINGS POSSIBLE

Would you like to support innovative educational projects at ETH, thus helping outstanding talent further develop Switzerland as an economic and scientific centre? We would be happy to talk to you about the various opportunities for getting involved.

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